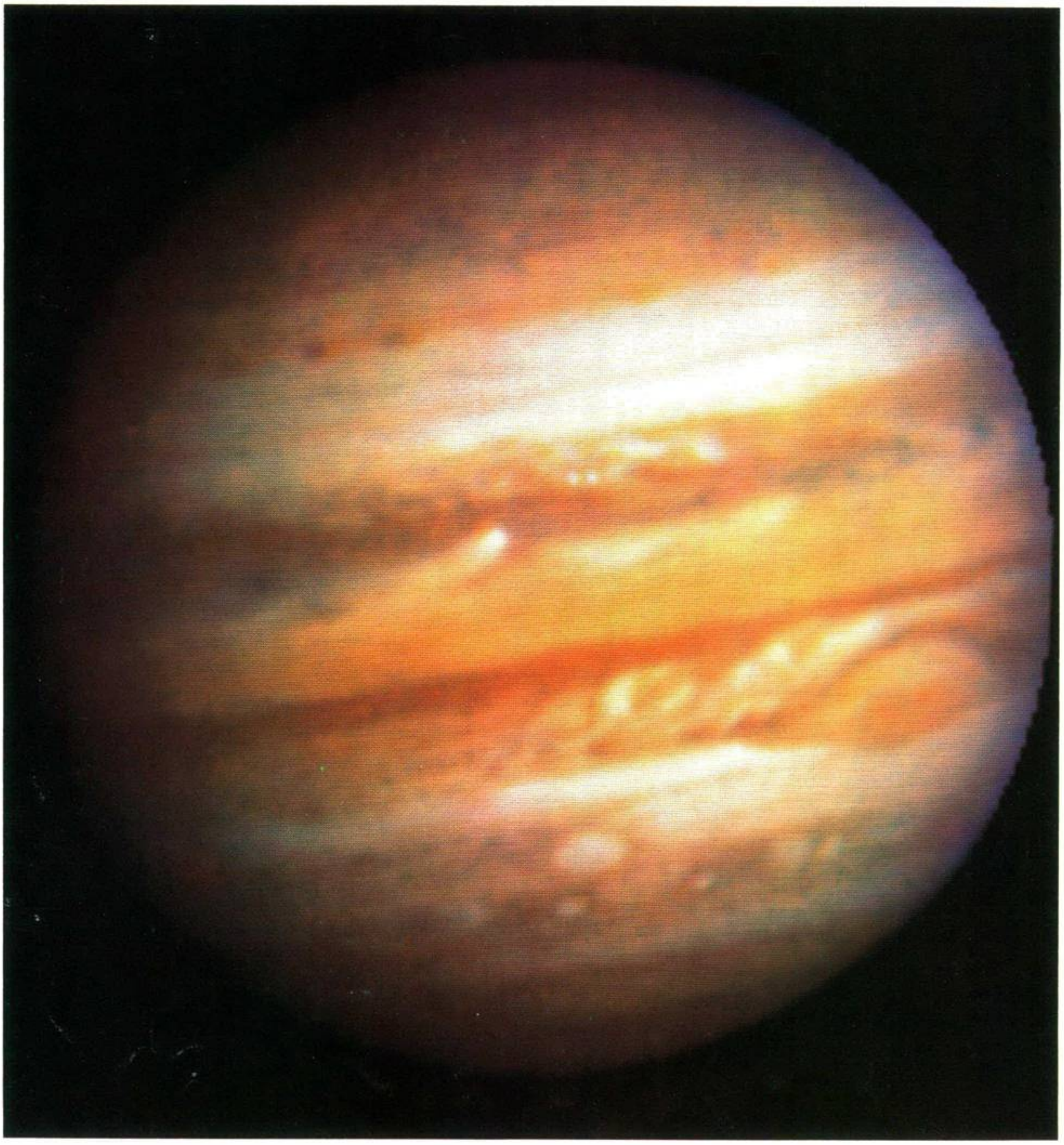
ASTRONOMY

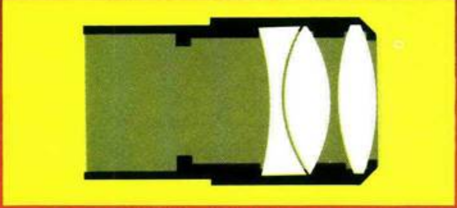
MARCH 1979 $2.00



Edmund Scientific has engineered a breakthrough in eyepiece design and pricing.

Innovation has rarely been so successfully applied as in the development of our new line of top-performance, moderately-priced RKE Eyepieces. Simply stated, we wanted to exceed the performances of widely-used American and foreign made eyepieces costing up to 60% more.

Our engineers used computer analysis to evaluate both the strengths and weaknesses of the best eyepieces available today. From these data, it was determined that with proper design and glass selection minimal aberrations could be achieved with only 3 optical elements, resulting in a substantial cost savings. Full ray-traces of all aberrations applied to glasses of high refractive index enabled Edmund to develop this unique 3-element system which equals or exceeds the performance of eyepiece designs using more optical elements.



The exclusive design of the RKE Eyepiece family coupled with the quality of its optics admits more light, is free from false colors and offers a sharply-focused, wide-field view of 50°.

The three RKE focal lengths were chosen to provide maximum versatility for your telescope. With par-focal design and comfortable eye relief these eyepieces are convenient to use. A red rubber ring provides easy identification and a sure grip in the dark.

The RKE's are American made in our own optical facility using only the finest optical glasses with effective anti-reflection coatings. They are eyepieces we are proud to offer and that you'll be proud to own.

You can improve the performance of your telescope today at a remarkably affordable price with any or all of Edmund's new family of RKE's.

Order today with the coupon. Your complete satisfaction is guaranteed. (OEM and dealer inquiries are invited.)

The Edmund RKE™ Breakthrough:

A new standard in eyepiece performance at a price you can afford.

"The RKE Eyepiece yields incredibly good definition over the entire field of view. It outperforms eyepieces costing twice as much."

— Terry Dickinson

"Tremendous apparent field, combined with comfortable eye relief make the RKE 28mm the most spectacular deep-sky eyepiece I've ever used."

— Leo Henzl

RKE 28mm
RKE 15mm
RKE 8mm

28mm Eyepiece
No. 30,787

Effective F.L.	28.7mm
Eye Relief	24.5mm
Apparent Field	50°
Field Stop Dia.	23.3mm
Barrel O.D.	Std. 1¼" (31.8mm)

15mm Eyepiece
No. 30,819

Effective F.L.	15.0mm
Eye Relief	13.4mm
Apparent Field	50°
Field Stop Dia.	11.9mm
Barrel O.D.	Std. 1¼" (31.8mm)

8mm Eyepiece
No. 30,820

Effective F.L.	8.0mm
Eye Relief	8.2mm
Apparent Field	50°
Field Stop Dia.	6.6mm
Barrel O.D.	Std. 1¼" (31.8mm)

Each $29.50

EDMUND
SCIENTIFIC COMPANY

EDMUND SCIENTIFIC CO. Dept K-06 Edscorp Building, Barrington, NJ 08007

☐ YES, please send me the following RKE Eyepieces at $29.50 each plus $1.00 service and handling charge. I realize that I must be completely satisfied or return the eyepiece(s) within 30 days for a full refund.

Qty.
_______ 28mm Eyepiece(s) No. 30,787
_______ 15mm Eyepiece(s) No. 30,819
_______ 8mm Eyepiece(s) No. 30,820

☐ Please send me latest FREE Edmund Catalog (K-06)

☐ Enclosed find ☐ Check ☐ Money order for total of $ _______
☐ Please charge my ☐ Am Exp. ☐ BAC ☐ MasterCharge
Card # _______________ Interbank # _______
Expir. Date _______ Signature _______________
Name _______________
Address _______________
City _______________ State _______ Zip _______
NJ residents please add 5% sales tax.

No. 101

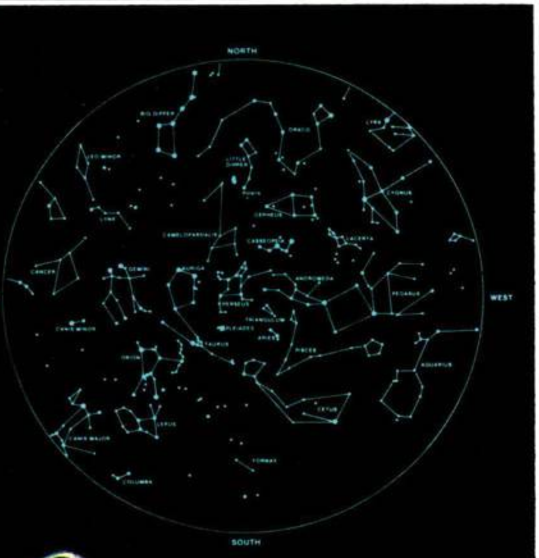
© 1979 Edmund Scientific Co.

THE YOUNG PEOPLE'S MAGAZINE OF ASTRONOMY AND OUTER SPACE

Odyssey

what's up? what's up?

THE THOROUGHLY MAGNIFICENT RICHARD AND ROBERT SHOW



Black holes . . . terraforming . . . double suns. "Star Wars" gone real! It's ODYSSEY, the first astronomy and outer space magazine designed just for young people. Exciting articles, out-of-this-world art, games, projects, puzzles, and much more. A sampling of monthly features:

The Thoroughly Magnificent Richard and Robert Show: Simple scientific experiments kids can do themselves.

What's Up? A monthly calendar of celestial happenings.

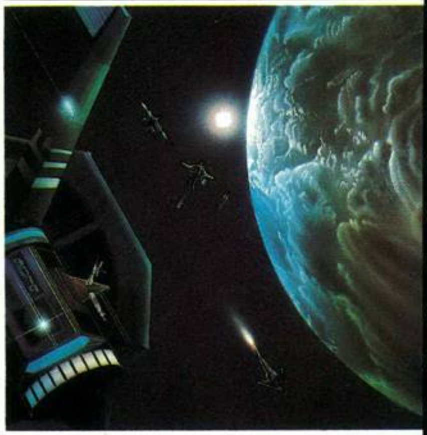
Find the Stars . . . and the Planets: A complete guide to the night sky.

All-Stars: Constellations, their stars and stories.

ODYSSEY Club: A collection of readers' drawings and discoveries.

ODYSSEY — the perfect gift for children 8 and older. Published monthly beginning in January 1979.

odyssey CLUB



all-stars

Yes! I want to introduce a child to Odyssey. Please enter a subscription for the term checked below:

☐ 1 year (12 issues) $12

☐ 2 years (24 issues) $22 (save $2)

☐ My check/money order is enclosed

☐ Please charge my credit card:

☐ Master Charge ☐ BankAmericard/Visa

Expiration Date ______

Account No. ______

Signature ______

Canada/Mexico, add $1.50 per year; all other foreign, add $3 per year. Please remit in U.S. currency or equivalent.

Please send Odyssey to:

Child's Name ______ Age ______

Address ______

City ______ State ______ ZIP ______

(This information is important for our records)

MY Name ______

Address ______

City ______ State ______ ZIP ______

Charter issue and official membership card will be mailed to the recipient, along with a card announcing your gift.

Make checks payable to: AstroMedia Corp.
411 E. Mason St., 6th Floor, Milwaukee, WI 53202

AMKID

(detach and mail in envelope provided)

Calendars from ASTRONOMY

SPACE 1979 is bigger
and
more beautiful than ever!

SPACE
1979
An ASTROMEDIA Production

Actual size (closed): 11-3/4" x 11-3/4"

$5.95 each*

1979
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

The 1979
ORION
CALENDAR

Actual size: 22" x 34"

$3.00 each*

SPACE 1979 features 12 full color varnished reproductions of some of the best space art and photographs that have appeared in ASTRONOMY, and each is accompanied by a short, easy-to-understand description. From a solar eclipse to the Magellanic Clouds, you'll want to frame these stunning reproductions!

Printed on coated 80 lb. paper, SPACE 1979 is spiral bound and "hole punched" for convenient hanging.

Hallmarks of ASTRONOMY's quality and beauty epitomize this distinctive calendar — whether the illustrations are framed immediately, or the calendar hung and used throughout the year.

Exciting features include:

- **Full color, varnished art & photos**
- **Punched for hanging**
- **Planet oppositions & special sky events noted**
- **Room to jot birthdays & other appointments**
- **1979 calendar**

Added Bonus:

- **3-year calendar**
- **Important dates in the history of astronomy and space exploration**

1979 is just around the corner. And to celebrate its arrival, we've designed a magnificent, decorative wall poster calendar.

This huge, quick-reference calendar (the full year at a glance!) shows the breathtaking Great Nebula in Orion. Photographed by one of the country's leading freelance astrophotographers, Orien A. Ernest, this detailed blowup exhibits all the colorful splendor found in the universe.

The drama of the intense reds and blues — the dark rifts of dust in this beautiful emission nebula will excite and amaze you as you reflect on the fact that new stars are forming there.

The simple elegance of the 1979 Orion Calendar will grace any wall — whether office, study, classroom or bedroom. And it will make an excellent gift, too — for anyone, of any age.

Each frameable lithographed reproduction is printed on 100 lb. paper and varnished. And the quality is uncompromisingly excellent! To insure that the Orion Calendar reaches you in A-1 condition, it will be rolled, and shipped to you in a sturdy mailing tube.

SPACE 1979 and the 1979 ORION CALENDAR are *timeless* gifts.

Quantity	Item	Price	Total
	Space 1979	$5.95	
	1979 Orion Calendar	$3.00	
	Space 1979/1979 Orion Calendar set	$7.95	
		TOTAL	

— *Special Offer —
If you order both SPACE 1979 and the 1979 ORION CALENDAR, we'll give you $1.00 off your total purchase price of $8.95 . . . that's both calendars for ONLY $7.95!

Name ________________ (please print) Date: ________

Address ________________

City ________ State/Prov. ________ Zip ________

Please allow 4 to 6 weeks for delivery.

Send check or money order to:
ASTRONOMY
411 E. Mason St. - 6th Floor
Milwaukee, WI 53202

Payment must accompany your order.
(Please remit in U.S. funds or equivalent.)

ASTRONOMY

The World's Most Beautiful Astronomy Magazine

Vol. 7, No. 3 March 1979

Established by Stephen A. Walther

Editor
Richard Berry
Associate Editor
Robert Burnham
Associate Editor
Dewey Schwartzenburg
Editorial Administrator
Katherine King
Production Manager
David A. Schwartz

President, AstroMedia Corp.
Robert A. Maas
Advertising Director
Robert Schmall
Comptroller
Dennis K. Wilk
Circulation Manager
Rosemary Pickart
Staff:
Dianne Precourt Cuneo
Maggie Espinoza
Nancy Faustmann
Stephanie Kiel
Elizabeth Lauer
Bruce Precourt

Production Photography
Communi-Graphics, Inc.
Color Separations
Colorcraft, Inc.
Production Consultant
William G. Stanfield
Printing
E. F. Schmidt Co.

6 **The Grand Adventure**
by Dewey Schwartzenburg and Robert Burnham

62 **Hektor: a Strange Asteroid?**

Stellar Frontiers 34 **How Stars Lose Their Cool**
by David Darling

Equipment Atlas 51 **Nebular Filters**
by Richard Berry

Gazer's Gazette 42 **Patrolling the Planets**
by Robert Burnham and Dewey Schwartzenburg

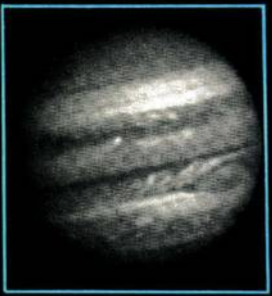
Sky Almanac 27 **Focus on the Outer Planets**

Astro-News 55

Astronomy Reviews 64

Astro-Mart 66

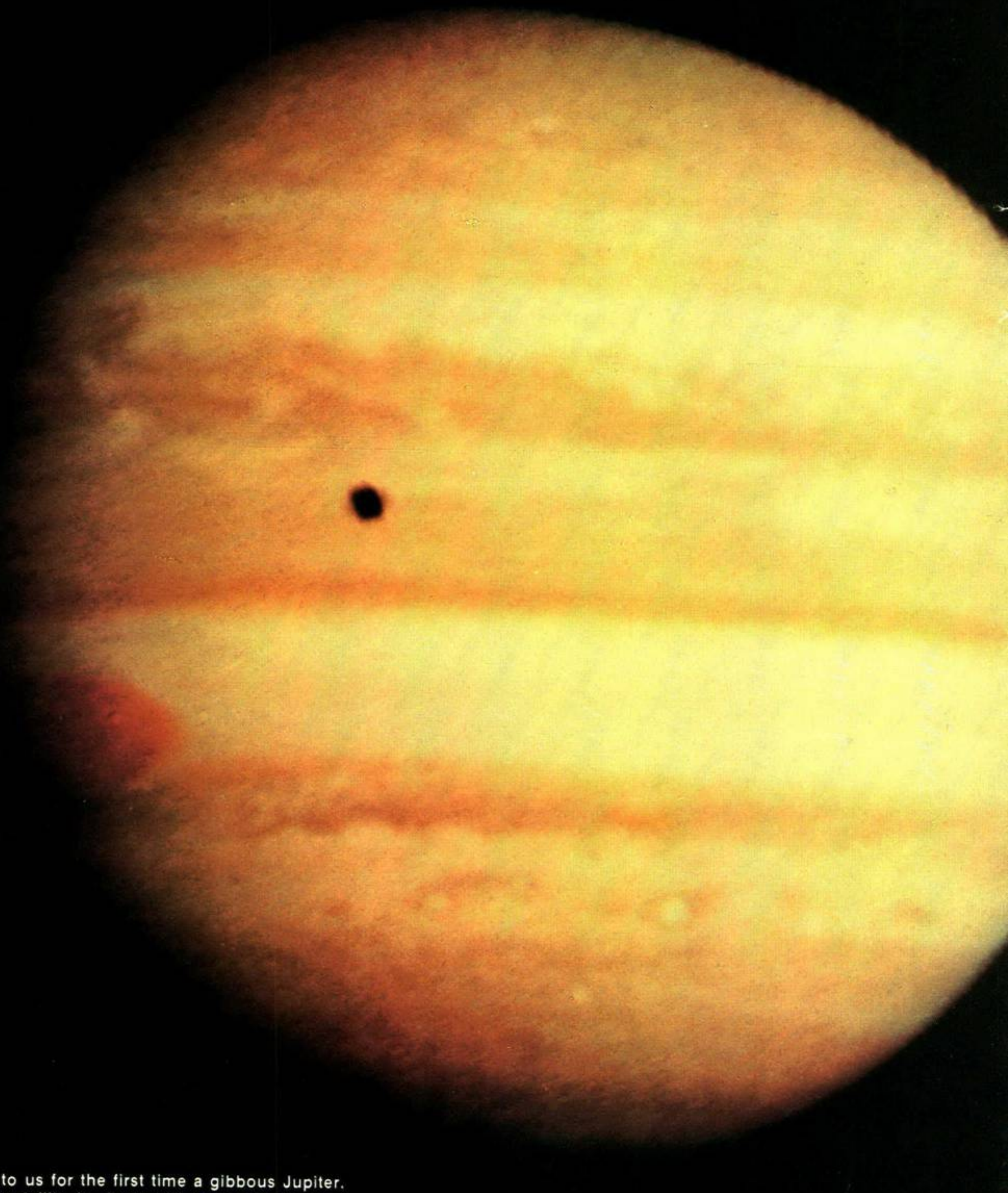
Star Dome 73 **Puppis**



Cover
On March 5, the American Voyager 1 spacecraft will fly past Jupiter, probing that planet and five of its satellites. After the encounter, it will then proceed toward rendezvous with Saturn. This remarkably detailed picture was taken by the craft's powerful telephoto cameras on December 10 — three months before encounter — from a distance of 52 million miles! If all goes well, scientific instruments aboard the craft will return a nearly unbelievable wealth of information about the planet and its mysterious moons. Yet all is not well with the American space program — funding cuts and cancellations may mean that the era of effective American planetary exploration is nearly over. NASA Voyager photograph 1-1.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 411 E. Mason St., P.O. Box 92788, Milwaukee, WI 53202. Copyright © 1979 AstroMedia Corp., all rights reserved. No part of this issue may be reproduced by any mechanical, photographic or electronic process or otherwise copied for public or private use without written permission of the publisher. Second class postage paid at Milwaukee, WI. POSTMASTER: When undeliverable, send form 3579 to publisher. Direct all inquiries, complaints, editorial submissions and other correspondence to ASTRONOMY, 411 E. Mason St., P.O. Box 92788, Milwaukee, WI 53202. Telephone (414) 276-2689. Not responsible for unsolicited materials. Please allow six to eight weeks for new subscriptions and changes of address to take effect. Due to the limited availability of back issues, new subscriptions must start with the most current month's issue. Cover price: $2.00. Subscription price: 1 year, $15.00. Canada & Mexico: add $3.00 per year. All other foreign: add $6.00 per year. Please remit in U.S. funds or equivalent. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of all issues of ASTRONOMY are available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 46691.

The Grand



Pioneer 10 revealed to us for the first time a gibbous Jupiter, shown here with its satellite Io. In transit across the face of Jupiter is Io's shadow, while the famed Great Red Spot lies near the morning terminator. It is just this alteration of our perspective — sometimes subtle, sometimes dramatic — that has been perhaps the most valuable contribution of the space program. NASA photograph.

Adventure

by
Dewey Schwartzenburg and Robert Burnham

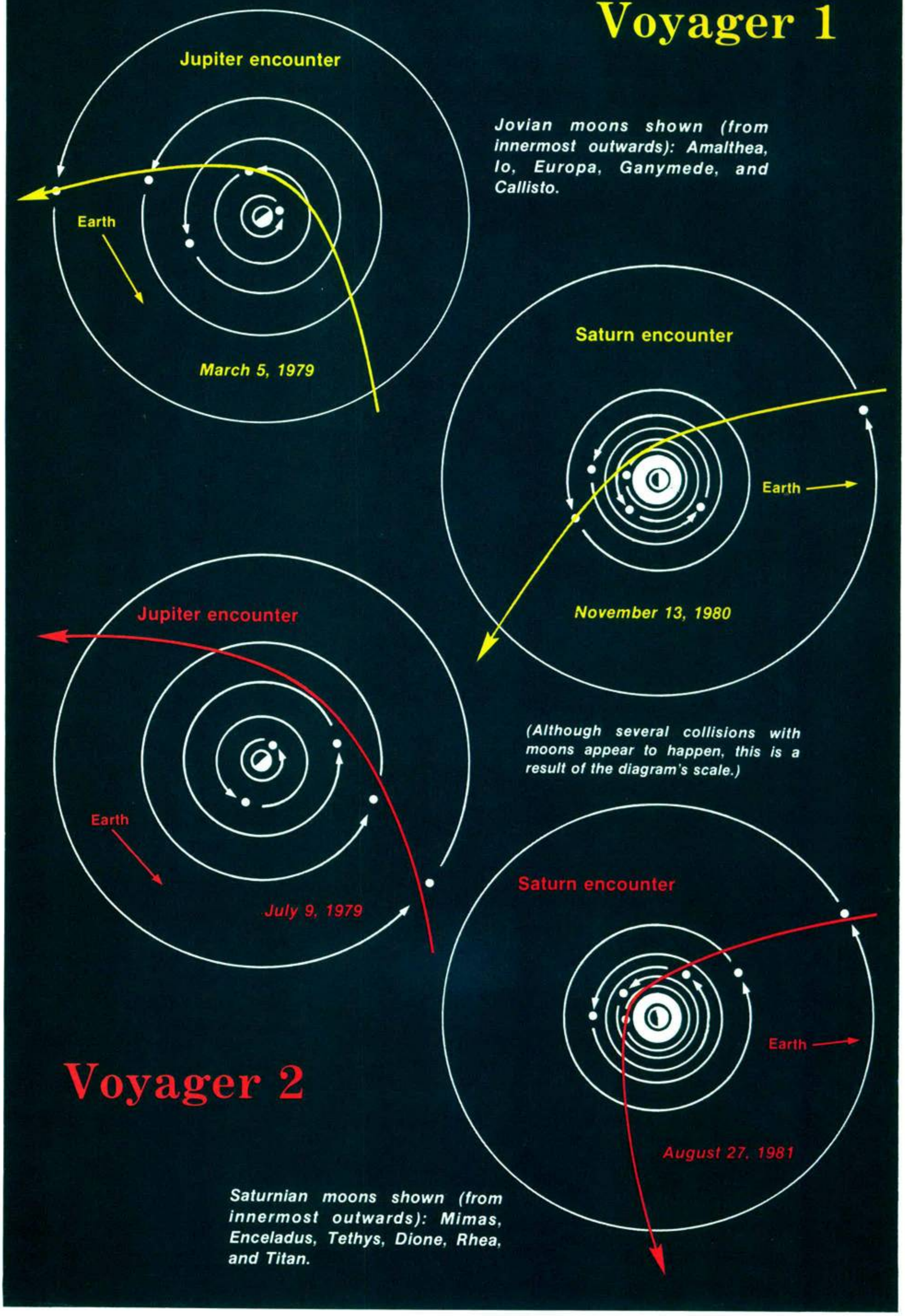
In recent years man has embarked on a voyage of discovery unparalleled in history. At this very moment we are engaged in a task beyond the wildest dreams of preceding generations: exploring the solar system! Barely two decades have passed since the first tiny packages of instruments were laboriously lofted above Earth's atmosphere to circle our home planet in orbits no higher than the distance from San Francisco to Los Angeles. Since then, men have walked on the moon, and large, complex robots have been sent to all parts of the solar system, journeying many millions of miles on missions lasting years.

We have seen a sunset over the ruddy horizon of Mars and an Earthrise beyond the limb of the moon. We have gazed down on the swirling maelstrom of Jupiter and sampled the poisonous atmosphere of torrid Venus. We have mapped the fabled moons of Mars and measured the craters of Mercury. The eyes of this generation are the first in the history of our planet to have seen the far side of the moon.

Less dramatic but more important is our growing understanding of the structure, dynamics and origin of the solar system. The leap in knowledge from the epicycles of Ptolemy to the telescopic observations of this century is less than that which has occurred in the last two decades. For example, geology and meteorology, two formerly independent sciences, are being seen more and more as specialized areas of a broader new discipline — *planetary science*.

But our exploration has only just begun. Columbus has sailed forth and returned: We know merely that there's a whole new continent to explore. Only the first small, tentative expeditions

Voyager 1


Jupiter encounter
Earth
March 5, 1979
Saturn encounter
Earth
November 13, 1980
Jupiter encounter
Earth
July 9, 1979
Saturn encounter
Earth
August 27, 1981

Jovian moons shown (from innermost outwards): Amalthea, Io, Europa, Ganymede, and Callisto.

(Although several collisions with moons appear to happen, this is a result of the diagram's scale.)

Voyager 2

Saturnian moons shown (from innermost outwards): Mimas, Enceladus, Tethys, Dione, Rhea, and Titan.

have been sent out, and still much survey work remains to be done. Saturn will be reached for the first time this year, while beyond lies the whole outer solar system, untouched. Right now, data are pouring back to us from Jupiter, and a mountain of new information about Venus is being processed and studied.

December 1978 may go down in the history books as the month of Earth's invasion of its sister planet Venus! A total of 10 spaceships swarmed to the neighboring planet in four waves. Six of these were probes designed to fall through the atmosphere to the surface — two Russian and four American — while a fifth American probe analyzed the upper atmosphere just before burning up in the thick lower layers. All the American probes worked perfectly, returning an enormous amount of information about the strange Venusian atmosphere. While they were not intended to survive the surface impact, one of the probes endured the searing heat and crushing pressures at the planet's surface for an additional 67 minutes.

Indeed, it is chiefly the atmosphere of Venus which has intrigued astronomers and planetary scientists in the past few years. It has turned out to be far more alien and complex than was ever imagined before the advent of solar system exploration! Among the mysteries which the two recent American missions, Pioneer Venus 1 and Pioneer Venus 2, were intended to explore are the present atmospheric composition and its dynamics, with a look to its probable origin and evolution over the eons. The great question, of course, is *why* Venus, very much like Earth in so many ways, has such an entirely different atmosphere! And the question is not without relevance for us back here on our home planet. Climatologists and others have begun to suspect that Earth's atmosphere is the result of a delicate and unique balance of factors — a balance that our modern technological civilization may now be tampering with dangerously.

Venus is far hotter than it should be, even allowing for its lesser distance from the sun. It seems likely that this is due to what has been called a "runaway greenhouse effect" in which solar radiation, admitted to the surface by the atmosphere, is prevented from escaping again by carbon dioxide. The rising temperatures might have led to atmospheric chemical changes rendering it even more opaque to the passage of heat radiation. Thus the temperatures may have risen higher and higher, reinforcing the process in a vicious cycle. Could *this* happen to Earth, with the average temperature soaring to 400 degrees Fahrenheit or more, because of only a few percent increase in carbon dioxide? It doesn't seem likely, but until we understand what happened to Venus, we can't be sure.

The upcoming encounters with Jupiter and (later) with Saturn are shown here in diagrams seen from over the planets' north poles. At Jupiter, the positions of the four Galilean moons and Amalthea are shown at the time of flyby. For Saturn, the moons inside of Titan's orbit are shown, again in their locations during the spacecraft pass.

Another important question is what powers the high winds driving the clouds of Venus? Swirling around Venus at speeds hundreds of miles an hour faster than the planet's rotation, the clouds present a meteorological puzzle of the first order! Our probes have measured the velocities in the clouds at a number of different points, while sampling their chemical composition, density, and temperature at various altitudes.

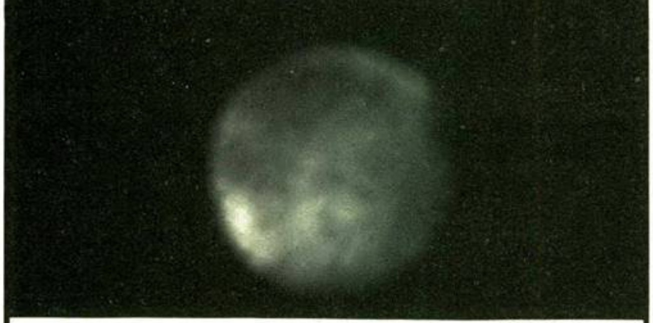
One spacecraft in the American fleet took up a reconnaissance orbit about the planet, swinging from a low point of about 100 miles to a high of about 40,000. It will remain in operation, we hope, for at least one full Venusian day (243 Earth days). One of its missions is to provide a simple map for most of the surface, using radar to penetrate the obscuring cloud cover. Venus' weather will also be studied, with satellite weather photos taken in ultraviolet light each Earth day.

A side benefit from the orbiter's mission will be a determination of the exact shape and internal mass distribution of Venus. It's important to know all we can about this because of a strange and unexpected phenomenon recently discovered: Whenever Venus is closest to Earth, it has the same side turned toward us! That is, Venus' rotation is somehow locked onto Earth just like the moon's is, but the dynamics of how this could come about for a planetary body the size and distance of Venus isn't known. The mystery will deepen further if it's found that Venus has a fairly uniform, symmetrical structure. With no noticeable "bulge" in the direction of Earth, scientists will be at something of a loss to explain the strange rotational lock.

The two Russian missions were identical. Each spacecraft separated into two parts, one of which descended to the surface of Venus while the other flew on by the planet. Nothing was placed into a Venus-circling orbit.

As we go to press, even while the data from the Venus probes are still being analyzed, another complex spacecraft is gearing up for an encounter with its first target: the giant planet Jupiter. Launched in September 1977, the craft is only now nearing the first of its two goals, some five astronomical units from Earth. The spacecraft, Voyager 1, is one of two sister ships sent from Earth 1-1/2 years ago on an important mission: exploring the outer planets. As it happened, Voyager 2 was launched first, but into a slower trajectory causing it to arrive at Jupiter four months later than Voyager 1.

These probes are the logical follow-ups to the two Pioneer missions to Jupiter (10 and 11) of several years ago. But many improvements in design have made the Voyagers more sophisticated and effective, putting to use the experience gained during the previous encounters.



Jupiter's 3rd moon, Ganymede

NASA photograph

Moons of Mystery

The Jovian system of moons contains a number of scientific puzzles. We won't get definitive answers with this mission, but the Voyagers should sharpen the focus on our very fuzzy images of these mini-worlds.

One puzzle is why the moons fall into three well-separated families, each of which has its own distinctive dynamical and physical features. The innermost of the three satellite groups consists of the four Galilean moons and Amalthea (J5). These five all stay close to Jupiter: Callisto, the most distant, orbits at 1.9 million km (13 Jupiter diameters). They're similar also in that all revolve around Jupiter in the same direction (*prograde*), their orbits are closely circular (average eccentricity = 0.001) and they lie within a degree of the planet's equatorial plane.

The second group, containing Leda (J13), Himalia (J6), Lysithea (J10) and Elara (J7), orbits about 11.6 million km from Jupiter. This group's orbital direction is also prograde, but compared to the innermost group, their eccentricities are larger (average = 0.160), and the orbital inclinations (to the plane of Jupiter's orbit around the Sun) are greater, averaging 27°.

The outermost family, made up of Ananke (J12), Carme (J11), Pasiphae (J8) and Sinope (J9), has striking differences. All four circle Jupiter (at a distance of about 23 million km) in the opposite sense from the others, that is, *retrograde*. Moreover, their orbital inclinations average about 60°, and their eccentricities are the highest of all, the mean being around 0.26.

Current scientific opinion about the outermost satellites is that they're most likely captured asteroids. Over the life of the solar system, the number of moons around Jupiter has probably been variable, with new members being picked up from time to time, and others wandering off.

A deeper riddle concerns the densities of the satellites. While only the "Big Four" — Io, Europa, Ganymede and Callisto — have density measurements reliable enough to mention, even this small sample reveals two populations. The inner two (Io and Europa) have densities like our own Moon, about 3.5 times that of water. The other two have densities that are about half this figure (average 1.8). From this, astronomers have drawn the conclusion that the inner ones are likely rock throughout (again, like our Moon), while the outer ones are mostly ice, with perhaps a small rocky core. *Why* is this, and what does it tell us about planet formation?

Scientists hope that the Voyager missions can provide answers to these riddles, or at least give us some hints! In addition, the more we can learn about the satellites now, the better the questions we can ask when the Galileo mission takes up orbital station around Jupiter a few years from now (see box on Project Galileo on page 14).

Pioneer 10, which flew past Jupiter in December 1973, provided scientists with the first close-up pictures of the planet, far surpassing in detail anything previously gained from ground based observations. It also gave the scientists a scare when it flew into the strong radiation belts around the planet. These zones of radiation, similar to the Van Allen radiation belts around Earth, proved to be far more intense than ever suspected. In fact, Pioneer 10 just squeaked past with its electronics intact! Only the ample safety margins in the original design prevented disaster.

This knowledge of conditions awaiting the following probe, Pioneer 11 (already well on its way), allowed mission planners to use its passage to best advantage. After a very successful flyby in December 1974, giving a look at Jupiter's polar regions for the first time, Pioneer 11 was retargeted to encounter Saturn. Its arrival at Saturn happens in September this year, and scientists are eagerly hoping that many important questions will be settled (or at least redefined!).

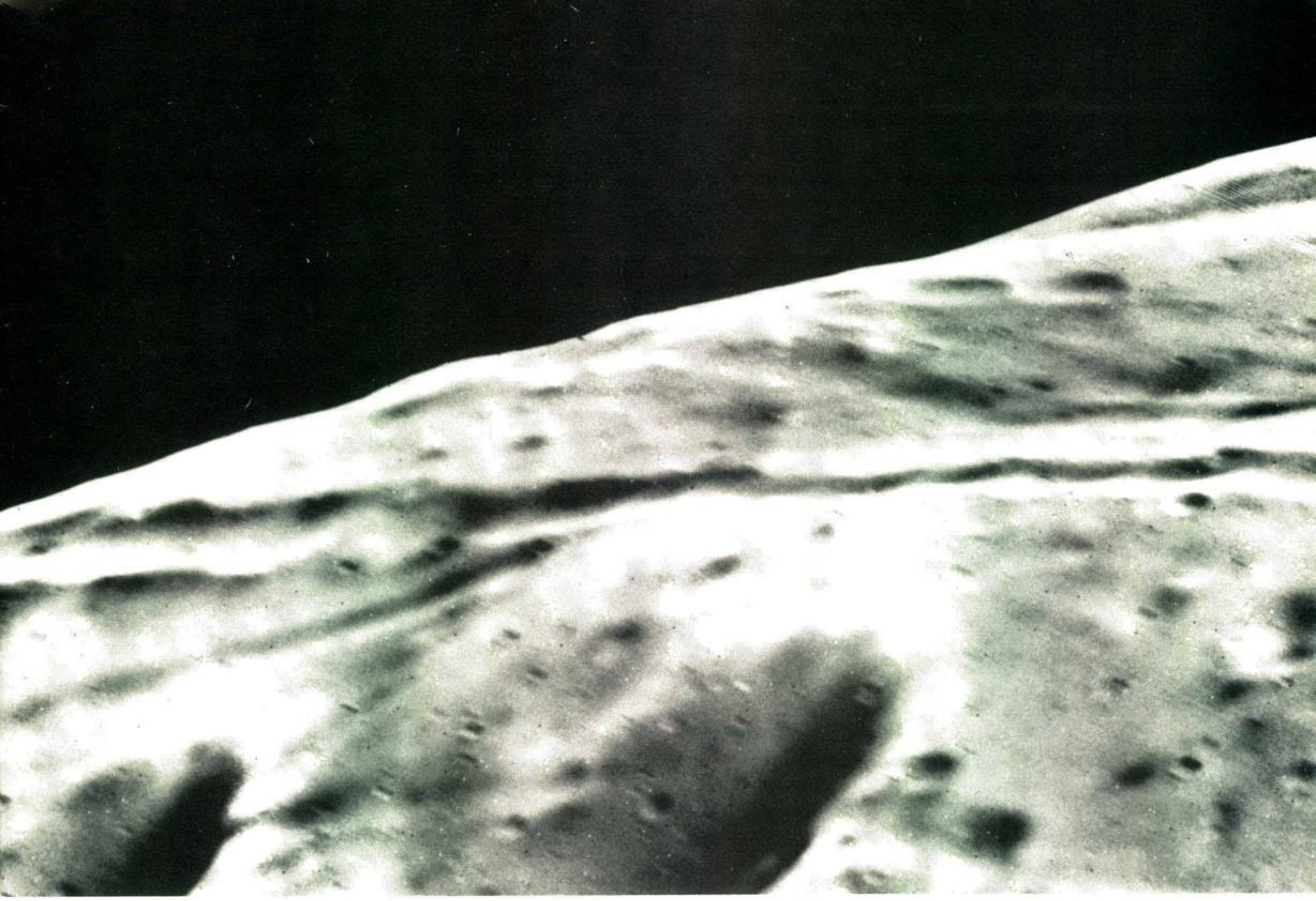
To take advantage of a rare alignment of the outer planets, NASA proposed several years ago a unique "Grand Tour" of the solar system, in which the planets Jupiter, Saturn, Uranus and Neptune would be sequentially visited by a spacecraft. Each planetary encounter would have aimed the craft on to the next target until eventually, after the Neptune pass, the probe would head slowly out into interstellar space.

But this ambitious and imaginative plan fell through, a victim of budget cuts. The present Voyager missions, however, will fulfill at least part of the Grand Tour, for after passing Jupiter and Saturn (provided it's still in good shape), Voyager 2 will be directed to fly past Uranus, with its newly-discovered ring system. There's even a remote possibility that Neptune could be visited, though much depends on the spacecraft's condition and its precise trajectory when it arrives at Uranus.

What do scientists hope to discover with the Voyager missions? Putting it briefly, *a lot*! The early Pioneer missions were designed for basic reconnaissance of the biggest two outer planets. The upcoming Saturn encounter of Pioneer 11 will help planners program the observations when the Voyagers finally arrive in 1981 and 1982.

The 11 experiments aboard Voyager are identical for both craft, and are aimed at gathering data on a wide variety of phenomena ranging from physical appearance to low-energy charged particles. For many people, the television pictures will be the most exciting results, but the other, more esoteric, experiments will help our understanding of the two planets as a whole, and are equally or even more important to planetary scientists.

One of the more easily accomplished experiments is a radio occultation, a technique that has been employed with each and every deep space probe sent out. It's based on the principle that as the



One of the ongoing mysteries of planetary geology are the striations or surface grooves marking much of Phobos. One theory explains them as deep fractures in the body of the satellite resulting from violent impacts. Elsewhere on Phobos is the 11 km diameter crater Stickney where scientists think the impact came very close to shattering Phobos entirely. NASA photograph.

craft passes behind an astronomical body, the manner in which its radio signals fade out and reappear tells a great deal about the structure, composition and extent of whatever planetary atmosphere is present.

The experiment also provides useful returns in the Doppler effect changes of the signal. The probe accelerates as it falls into the planet's gravity well, while the changes in velocity can be detected by frequency shifts in the radio signals. This gives scientists a simple and precise way to assess the mass of a body and the distribution of matter within it.

When the probes reach Saturn, the ring system there will be explored in the same manner. (This fall, Pioneer 11's flyby will give us an exciting preliminary look!) Scientists hope to get some accurate figures on particle sizes, density and structure of the ring system by means of this elegant technique.

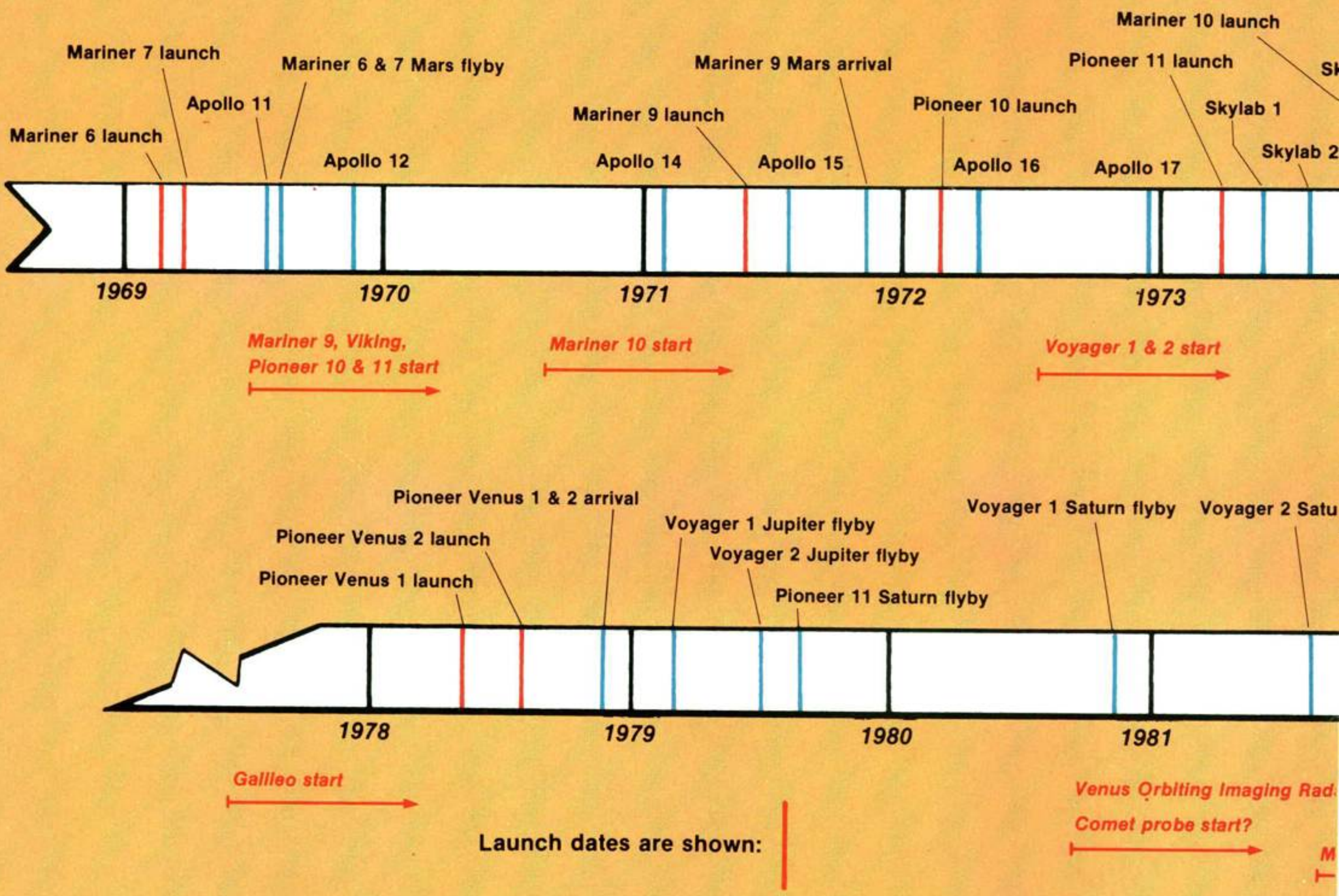
Jupiter has long been known to produce terrific bursts of radio noise at decimetric and decametric wavelengths. The origin of these bursts is largely unknown, though they appear to be related in some fashion to the planet's belts of charged radiation (magnetosphere) as well as its internal composition, rotation and the location of the satellite Io in its orbit! This not only *sounds* weird, it *is* — so in order to understand what's going on, a planetary radio astronomy experiment has been devised, for listening in at several wavelengths.

Saturn is an unknown quantity, though a safe prediction gives it a magnetosphere nearly as large and strong as Jupiter's. Accordingly, the experiment will also be run when the craft gears up for the Saturnian flyby. The sun, too, will be under surveillance, because positioning an instrument so far from Earth makes possible important cross-correlations when the data from the spacecraft are compared with ground measurements.

The size and extent of Jupiter's magnetosphere, determined by Pioneer 10, was a surprising discovery. The zone of trapped radiation extends out to 50 Jupiter diameters (7.1 million kilometers) — much farther proportionally than Earth's does. It also appears to be highly variable in extent, being sometimes compressed down to a (proportional) size that would be found on Earth only during the severest of solar storms.

Since Io apparently has some degree of control over Jupiter's radio bursts, the interaction of it and the other satellites with the Jovian magnetic field

The Slackening Pace of Planetary Explo



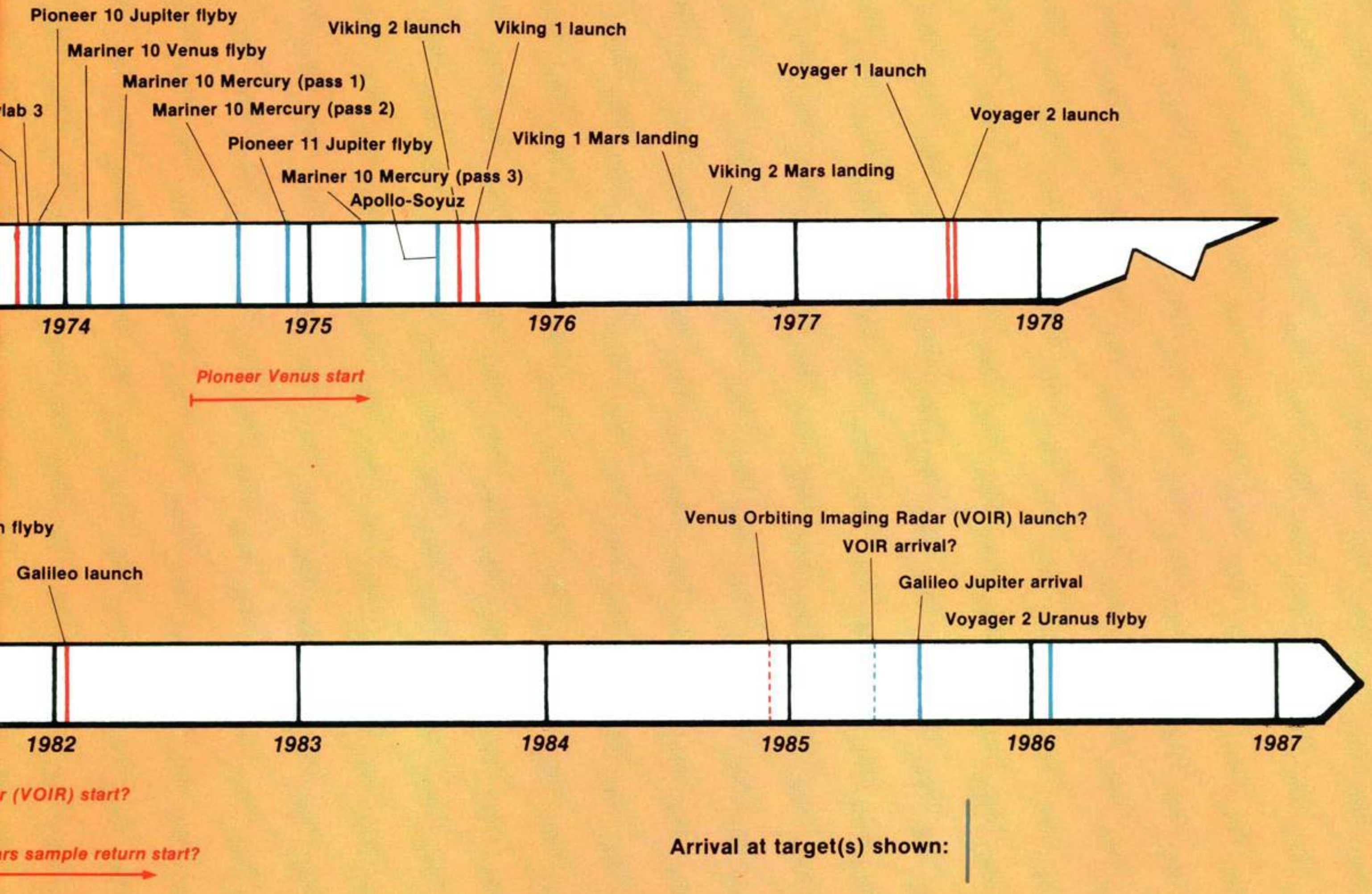
will be closely examined. Two of the four Galilean moons seem to be rocky, while the other two appear to be mostly ice. The rocky ones might have magnetic fields of their own, and the way these may interact with Jupiter's field will be studied carefully.

While it'll be many years before we're able to do a direct, hands-on sample analysis of Jovian material, we still can learn a great deal from analyzing how the planet reflects light. This is an old astronomical technique, long used in studies of solar system objects from Earth. As sunlight reflects from any material, the nature of that material imposes its own distinctive "signature" on the reflected light. Careful analysis coupled with laboratory experiments often allows rather good guesses to be made — without any direct samples being taken.

So scientists have on board a photopolarimeter, a device to measure the extent to which sunlight is polarized by the constituent materials of the planets' atmospheres or surfaces. In particular, they hope to learn about the methane and molecular hydrogen in the upper cloud layers of Jupiter, and the surface materials of its satellites.

The optical system of the instrument is basically a six inch Cassegrain telescope. In front of the focal plane is a wheel containing several filters. When the various filters are placed in the optical path, a photomultiplier tube at the focal plane senses and measures the brightness. Several viewing angles can be chosen: 3.5, 1, 0.25 or 0.063

ration



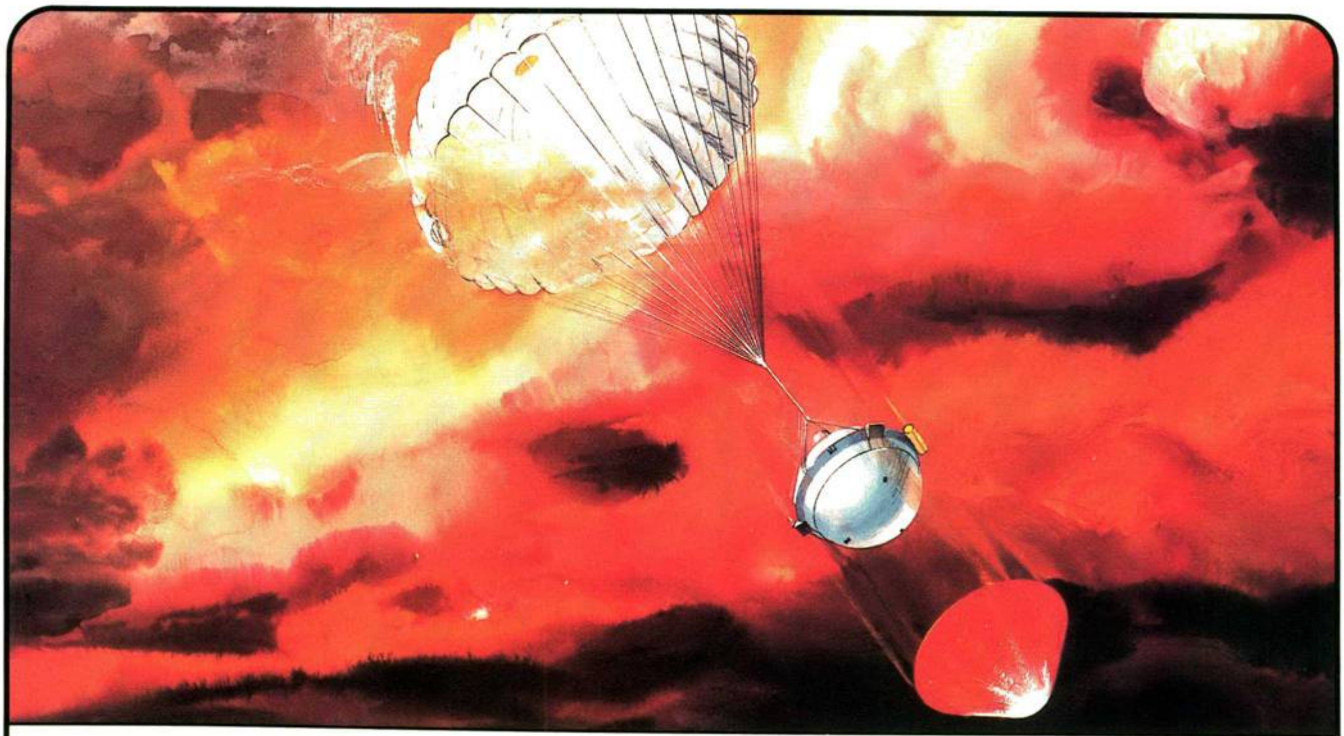
There are two problems facing mission planners who want to explore the outer solar system: funding and reliability. As the above time line shows, the start made on a particular project is usually long in advance of lift-off. Many people aren't aware that any one space mission requires years of thought and development — all of which cost money. Funding projects with an "on again, off again" basis accomplishes little. The other problem is technical: Spacecraft must be made to function reliably for years or even as much as a decade or more after launch! We're only now beginning to see ways to ensure this.

degrees, allowing closer looks at interesting small features.

Cosmic rays are high-energy, charged particles that pervade all of space. Known since the early 1930s, their origins are still a matter of debate. Onboard the craft is a detector experiment aimed at measuring the cosmic ray abundances and types, plus the composition of the particles in the magnetospheres of Jupiter and Saturn.

Jupiter's internal heat flow is of great interest because the planet is strangely giving off more radiation than it receives from the sun. Scientists want to construct a good "heat budget" for which precise measurements are needed to distinguish between the various models for the internal heat source. The job of assessing these has been given to the infrared spectroscopy experiment. In addition to the heat flow question, much will be learned about the surfaces of the satellites (and any possible atmospheres) from their infrared "signatures."

In order to determine the compositions and motions within the upper atmospheres of Jupiter and Saturn, another spectroscopy experiment is



NASA artwork by Ken Hodges

Project Galileo

Robot exploration of the solar system typically follows a three stage pattern: flyby, orbiter and lander. (Russian probes often bypass the second stage.) NASA has now explored the Moon, Mars and Venus by all three techniques, Jupiter and Mercury by the first only, while Saturn and the outer planets still await their first terrestrial visitors!

Project Galileo represents stage two of the exploration of Jupiter. Scheduled to be launched less than three years from now (in January 1982) aboard the Space Shuttle, the mission uses a two-part spacecraft. The first part is an entry probe which will plunge into Jupiter's soupy atmosphere behind a heat shield. When the probe has slowed to subsonic speeds, the shield is discarded and the craft falls by parachute for a distance. At a preselected depth in the atmosphere, the parachute is cut away, and the craft falls freely until the increasing pressure crushes the hull, about 30 minutes after entry.

During the descent, the probe will be examining several basic properties of the jovian atmosphere: composition, density, opacity and structure. The data are radioed to the other craft for eventual relay to Earth.

The second craft meanwhile has fired its braking engine and gone into a long elliptical orbit around Jupiter. Shortly after arrival, the orbiter part will adjust its initial orbit to one with a distance from Jupiter about equal to that of Ganymede's orbit. If all goes well, the following 20 months will be spent examining Jupiter's environment, using the gravitational attraction of Ganymede to alter the orbit slightly on each pass.

The orbiter's assignment includes making detailed examinations of the satellies' surface compositions and possible atmospheres, the charged particle densities and magnetic fields in the region of space around the planet, and doing a synoptic study of the jovian atmosphere. On board also is a five foot focal length camera to provide high-resolution pictures for scientists to study. The camera will use solid-state electronics instead of the present-day videcon (television) tubes to get better pictures and allow easier computer processing of the images.

The mission as a whole has been named *Galileo* to honor the scientist who discovered the four chief satellites of Jupiter with his newly-made telescope in 1610.

What does the future hold for jovian studies? One proposal, originating with Arthur C. Clarke (see his short story "A Meeting with Medusa"), would put a balloon probe adrift in the planet's atmosphere, to collect samples and analyze them directly.

(How would you make a balloon float in an atmosphere of hydrogen, the lightest element known? Simple, just heat it. After all, since a hot air balloon floats easily in *our* atmosphere, why shouldn't a hot hydrogen balloon float there?)

Although the plans for such a probe aren't yet on the drawing boards, there's nothing truly radical in the idea, and such a probe could return an unbelievable amount of data — data we need to understand the ways in which the "primordial soup" of the early solar system was cooked into planets!

being flown — this one looking at the ultraviolet. The instrument will also provide some data on the amounts and ratios of hydrogen and helium in interplanetary space, numbers needed to put constraints on theories of solar system origin.

The cameras onboard have been developed from the successful designs of the Mariner type, changed where necessary for Jovian and Saturnian conditions. Two lens systems have been sent: a 200mm "wide-angle" and a 1,500mm telephoto. The telephoto camera will be used for full-disk photos up until about 20 days before the encounter, when the disk will have grown larger than the field of view. At that point, the wide-angle camera will be used for overall shots, and the telephoto for selected targets.

Each camera has a filter wheel with eight filters, their different color transmissions allowing full-color reconstructions of the images. The wide-angle camera's wheel has one filter never before flown: a narrow-pass filter centered at the sodium D line, for special investigations of Io, the Jovian satellite which is surrounded by a halo cloud of sodium. On the approach to the planet, photos will be taken at intervals allowing scientists to construct a movie of the cloud top motions.

It's hoped that the first clear portraits of the Galilean moons will emerge from the mission, though many natural difficulties make the task far more complicated than reconnaissance of the inner solar system. The spacecraft will be moving very swiftly, and sunlight at distant Jupiter is only 1/25 as bright as at Earth. At Saturn, the lighting goes down to 1/100 of "Earth standard", and at Uranus, the level is only *1/400*! The television camera circuits have been rigged with special amplifiers to suppress noise and enhance the signals. Unsmeared short exposure photos should be possible, even with the low light levels.

When all has been accomplished with the Jovian encounter, where will we stand in our knowledge of that immense planet? Undoubtedly a great deal will have been learned and many questions will have been answered, but on the basis of previous planetary missions, we may expect that entirely *new* questions and mysteries will have been uncovered!

With each mission, we are really groping in the dark, building on past guesses that paid off. Because of the limited technology at our command, the bind we find ourselves in with planetary missions is critical. When you design a piece of hardware to fly on a mission, you are forced to make some sort of guess as to the experiment's most likely results. In many cases, this can be done with some assurance that you're not seriously off-base. Yet haunting many scientists is the possibility that we're asking only the trivially obvious questions and missing the jackpot. Science is usually the process of learning by experience just which questions are the useful ones.

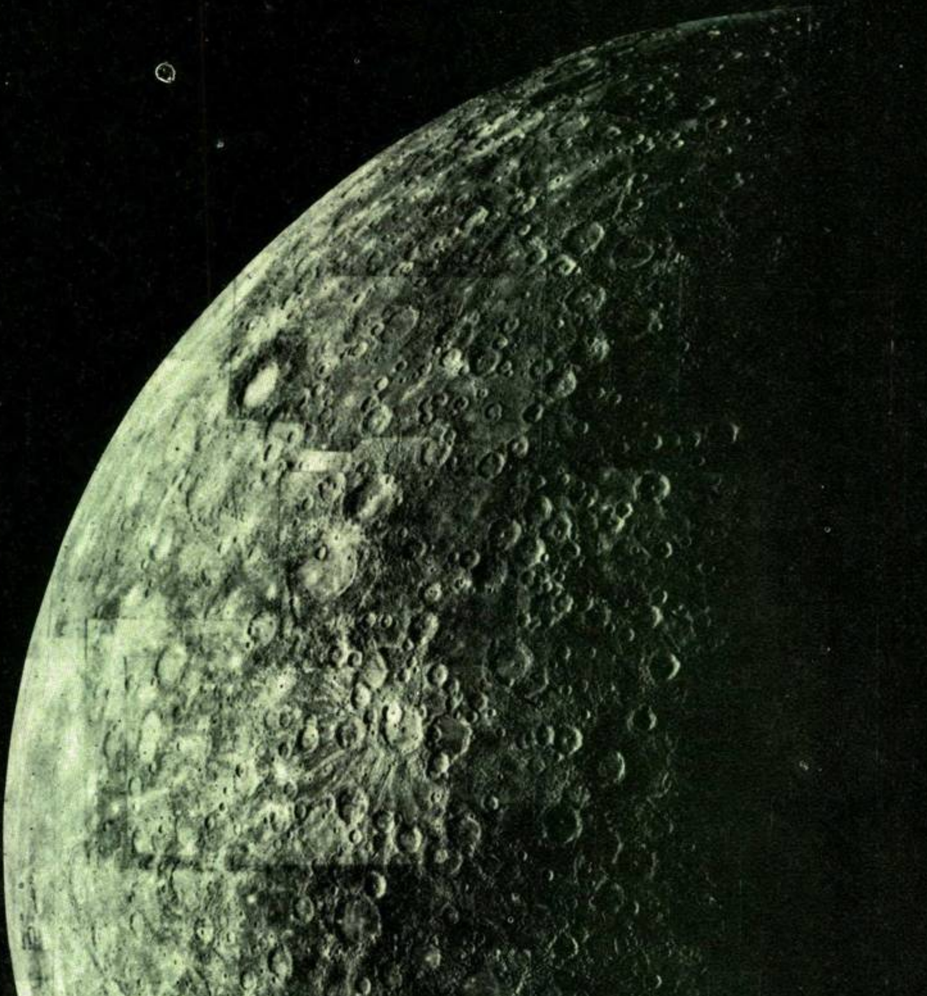
For example, by the end of the Apollo missions, the people working on them felt that at last they were getting to the point where they knew what the significant questions were — and then the program was canceled. As someone said, it seemed rather like buying a Rolls-Royce and then selling it right away because you felt you couldn't afford the price of gasoline! The accumulation of knowledge will remain about the moon, but the working team has been dispersed and will never reassemble again. To some extent, anyone who begins again to work on lunar problems will have to start afresh.

A more recent example is provided by the latest missions to Venus already discussed. They were by far the most sophisticated yet, but they were planned on the basis of information gained in preceding missions. The exploration of the solar system inevitably calls for a series of missions, as each one provides essential data for the planning of the next, more informative mission. This is clearly demonstrated in the case of the early Russian landers sent to Venus which, while confirming the extremely high temperatures reported by American probes, failed to survive in the intense heat. Later landers had to be carefully designed to endure the harsh conditions of the surface.

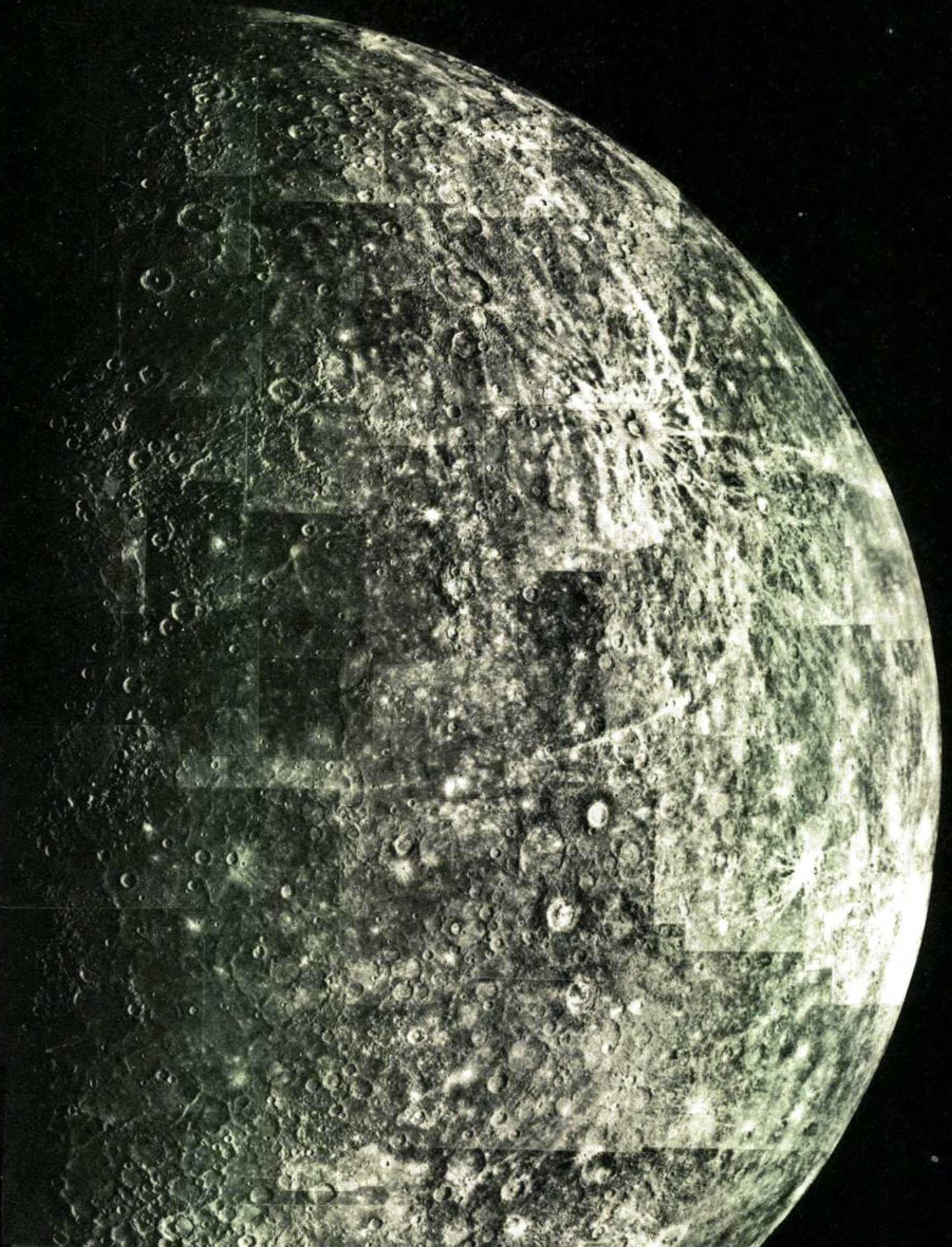
NASA is now planning a follow-up mission to Venus for 1984-85. Launched by the Space Shuttle, a Venus Orbiting Imaging Radar (VOIR) spacecraft would circle the planet for at least seven months, taking radar pictures and making measurements of the atmosphere as well as the surface. Dr. Noel W. Hinners, NASA's Associate Administrator for Space Science, has said, "NASA is engaged in a continuing program of space exploration, a major part of which is directed at the solar system. The VOIR program is a key step in that endeavor." While considerable knowledge of Venus' atmospheric properties will be gained from the Pioneer Venus mission, information about the structural properties of the planet's surface were not part of the Pioneer Venus program. VOIR would provide scientists with a detailed map of Venus, which would disclose the presence or absence of continents, ocean basins, mountain belts, rift valleys, fault belts or volcanos. The nature and time sequence of plate tectonic activity (continental drift) may also be revealed, as well as any relationship between this and volcanic episodes in the history of the planet. Other investigations would be conducted which relate to the planet's fundamental geophysical and atmospheric problems. Start-up of the program would have to take place in fiscal year 1980 — beginning October 1 of this year, but at the time of writing, inclusion of the VOIR orbiter in NASA's budget had not been approved.

Other deep space missions have also demonstrated the need for more sophisticated

continued on page 22



On this page we see the hemisphere of Mercury that was seen by Mariner 10 as it approached the planet. (This picture is a mosaic of many images, hence the lines and joints.) Prominent at the upper left near the limb is the bright-floored crater Lermontov surrounded by a dark halo of material. The small, rayed crater nestled inside a larger one is Kuiper, named for the famous planetary scientist. NASA photograph.



And here we see the "receding" side! This photomosaic reveals what Mariner 10 saw on the outbound leg of its flyby on the first of the three encounters. Many ray craters are evident. The freshest looking of the ray systems is perhaps that in the upper right center, formed by a doublet of craters, Bronte and Degas. At the midpoint of the terminator lie the eastern reaches of the Caloris Basin, a huge impact feature resembling Mare Orientale on the moon. NASA photograph.

What Are the Russians Up To?

by
James E. Oberg

The Soviet Union has long placed a high priority on the exploration of the solar system. The first probes sent into interplanetary space were launched by the Russians. Venera 1 in 1961 and Mars 1 in 1962 were the vanguard of fleets of robot explorers over the ensuing years — but they set a theme central to the Soviet interplanetary program: They both failed.

In later years, a persistent Soviet effort to send probes to Venus was ultimately crowned with triumph, while a less well-known but equally determined effort to land on Mars was to lead only to failure. Today, nearly 20 years after the first interplanetary efforts, Soviet engineers and scientists are considering the next steps in their program and the technological breakthroughs needed to sustain them.

In the next five years, Soviet Venus exploration will expand to include balloon probes floating in the atmosphere. The Soviet program for Mars is unknown, but will likely encompass roving vehicles on the Martian surface. Farther afield, Soviet probes to Mercury and Jupiter, including an entry probe which should land several years before the American Galileo craft, are possible.

Later in the 1980s, more ambitious undertakings can be forecast. Soviet spokesmen make no secret of their ultimate intention to make manned interplanetary flights, but no schedules are given and, in all probability, no budgets have yet been approved. But if current trends continue, a manned landing on Mars by Soviet cosmonauts is conceivable by about 1990.

Expanding on the success of the heavy Venus probes which appeared in 1975, Soviet space planners have signed an agreement with the French space agency to cooperate on the 1983 Venus atmosphere balloon. Delivered into the Venusian atmosphere by a Soviet spacecraft very similar to the recent Venera 11 and 12, the French-built balloon will suspend a gondola of scientific instruments which will circle the planet on the stratospheric winds for several days.

Between now and the 1983 launch, two additional Venus windows are available. More ambitious surface survival expeditions, like the ones mounted last December, are expected.

For Mars, the Soviets have always had a strong attraction but have had little satisfaction. The last Soviet Mars attempt was in 1973, when a fleet of four spacecraft, each weighing five tons, cast off on an ambitious attempt to upstage the planned Viking landings. One probe safely reached orbit and returned a few photos — the rest failed.

Observers believe that no new Mars probes will be launched until they can appear to be an improvement on the Viking landers of 1976. One key ingredient in such a mission would be mobility — a robot wheeled *Marsokhod* or Mars rover, patterned after the successful but generally unproductive *Lunokhod* moon jeeps of 1970-73. More advanced computer control systems would be needed, since direct remote control from Earth is impossible. References in the Soviet technical literature indicate that such research is indeed taking place.

No Soviet rocket has ever used the high energy capabilities of a liquid hydrogen and liquid oxygen system, first flown by the United States in 1965. The high power requires very advanced rocket technology which the Soviets have not yet demonstrated, but the payoff is so valuable that it is a logical next step to be used as the upper stage of Soviet deep space rockets.

Nor have Soviet space probes shown the long lifetimes, measured in years, needed to reach more interesting solar system targets. This requires advances in space electronics, or avionics, advances which the Soviets are also pressing forward on.

Together, these new technologies would allow Soviet photographic flyby missions to Mercury, on the side opposite the one photographed by Mariner 10, perhaps as early as later this year. And they would allow the launching of a spacecraft which European sources have been whispering about for more than a year: a Jupiter entry probe, launched on a direct impact flight lasting about 18 months. Such a probe, to be called *Yupiter 1*, might appear later in 1980, reaching Jupiter three years before Galileo.

Soviet interest in unmanned — and ultimately manned — interplanetary exploration is no secret. Present efforts have reached a plateau and new engineering breakthroughs can be expected in the coming year. The space race to the planets is still in progress.

The European Space Agency

The United States and the Soviet Union aren't the only countries engaged in the exploration of space! A number of European countries have space programs of their own, and increasing in importance during recent years has been an international body known as the European Space Agency (ESA).

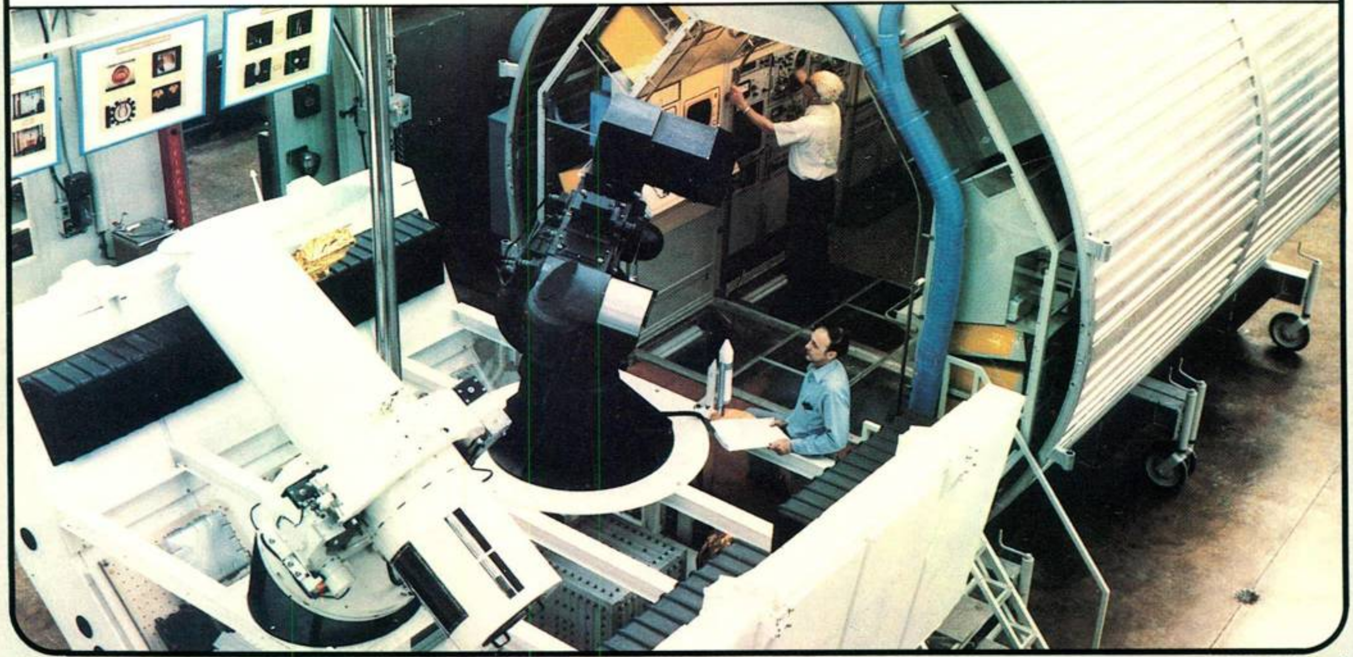
ESA was formed in 1975 out of the European Space Research Organization (ESRO) and the European Launcher Development Organization (ELDO). Member countries are Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. Each nation contributes a certain percentage of its gross national product to ESA's budget, which is quite modest by NASA terms. The total budget for 1978, for example, was $689 million, of which only a little over $98 million was devoted to space science. In fact, ESA has recently been under considerable pressure to devote more of its resources to scientific programs rather than applications such as communications satellites.

Nevertheless, ESA and its predecessor ESRO have an impressive record so far, and ambitious plans for the future. Thirteen scientific satellites have been launched since 1968 (one in conjunction with NASA), of which four had specifically astronomical missions. A recent ESA report stated that "an increased emphasis is being placed on astronomical studies." Two of ESA's upcoming projects reflect this commitment — both planned jointly with NASA: an out-of-ecliptic solar polar mission and the Space Telescope.

The out-of-ecliptic mission will involve the launch of two space probes in February 1983 which will fly by Jupiter, using that planet's gravitation to swing into orbits that pass over the sun's north and south poles. This will take it far outside the plane of the planetary orbits. ESA is also participating in the Space Telescope program, planned for launch from the Space Shuttle late in 1983. About 15 percent of the observing time on the orbiting telescope will be available to European astronomers.

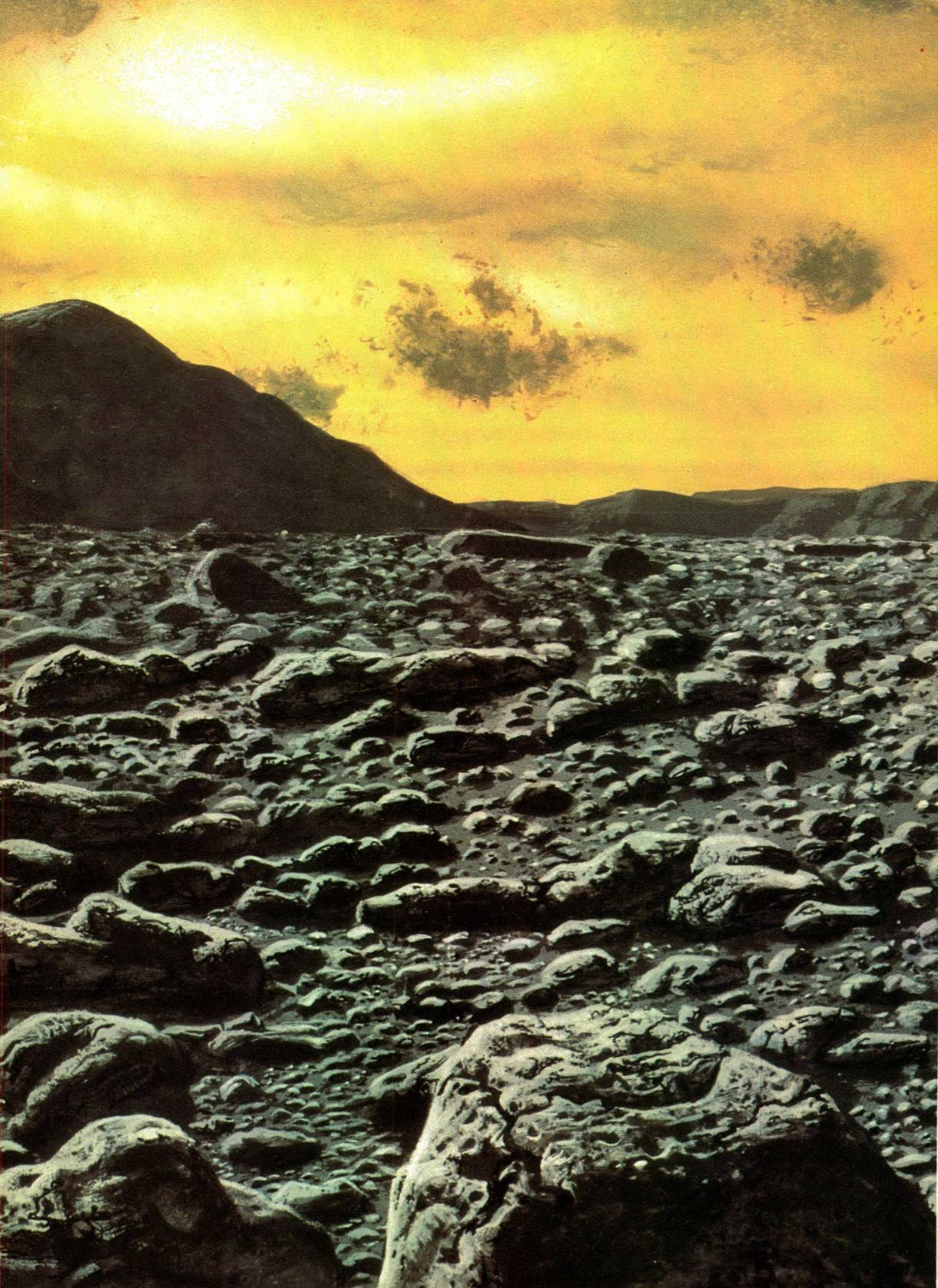
Other plans include a Spacelab payload on the 10th flight of the Space Shuttle and an x-ray astronomy satellite projected for launch in early 1981. Future possibilities now being considered for approval are an extreme ultraviolet and x-ray survey satellite, an astrometry satellite, a grazing incidence solar telescope and a polar orbiting lunar observatory. Presently, ESA makes use of American made launch rockets, but its own launcher, dubbed *Ariane*, is expected to be in service soon.

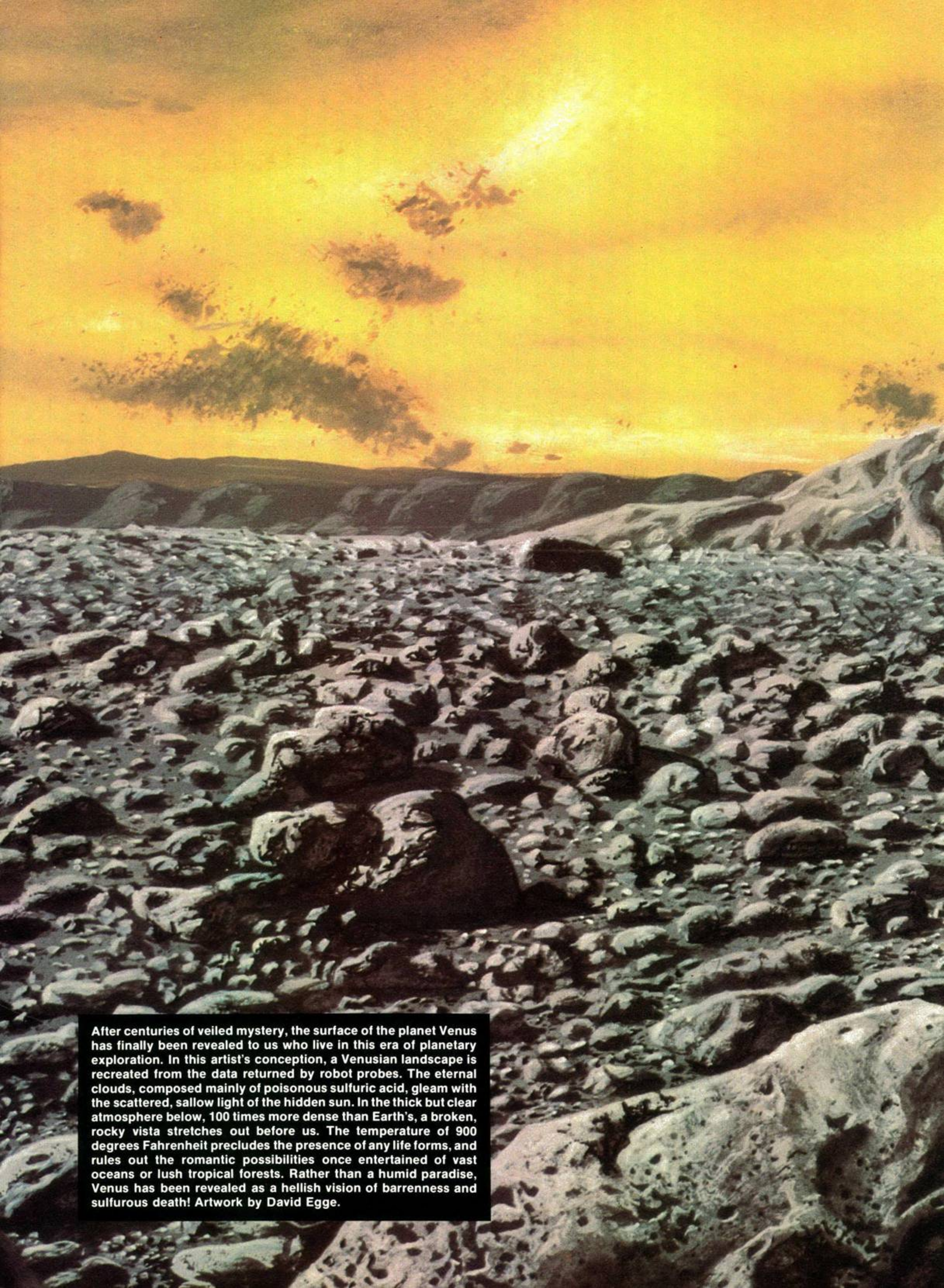
While no planetary missions have yet been approved by ESA, interest in such projects is increasing. One problem is shortage of money — a planetary mission costs considerably more than an Earth-orbital mission. Two ESA working groups, one devoted to astronomy and the other to exploration of the solar system, concluded that a minimal program for the next decade in *either* field would swallow up the entire science budget as it currently stands! The need for larger contributions from each of the participating countries has become clear.



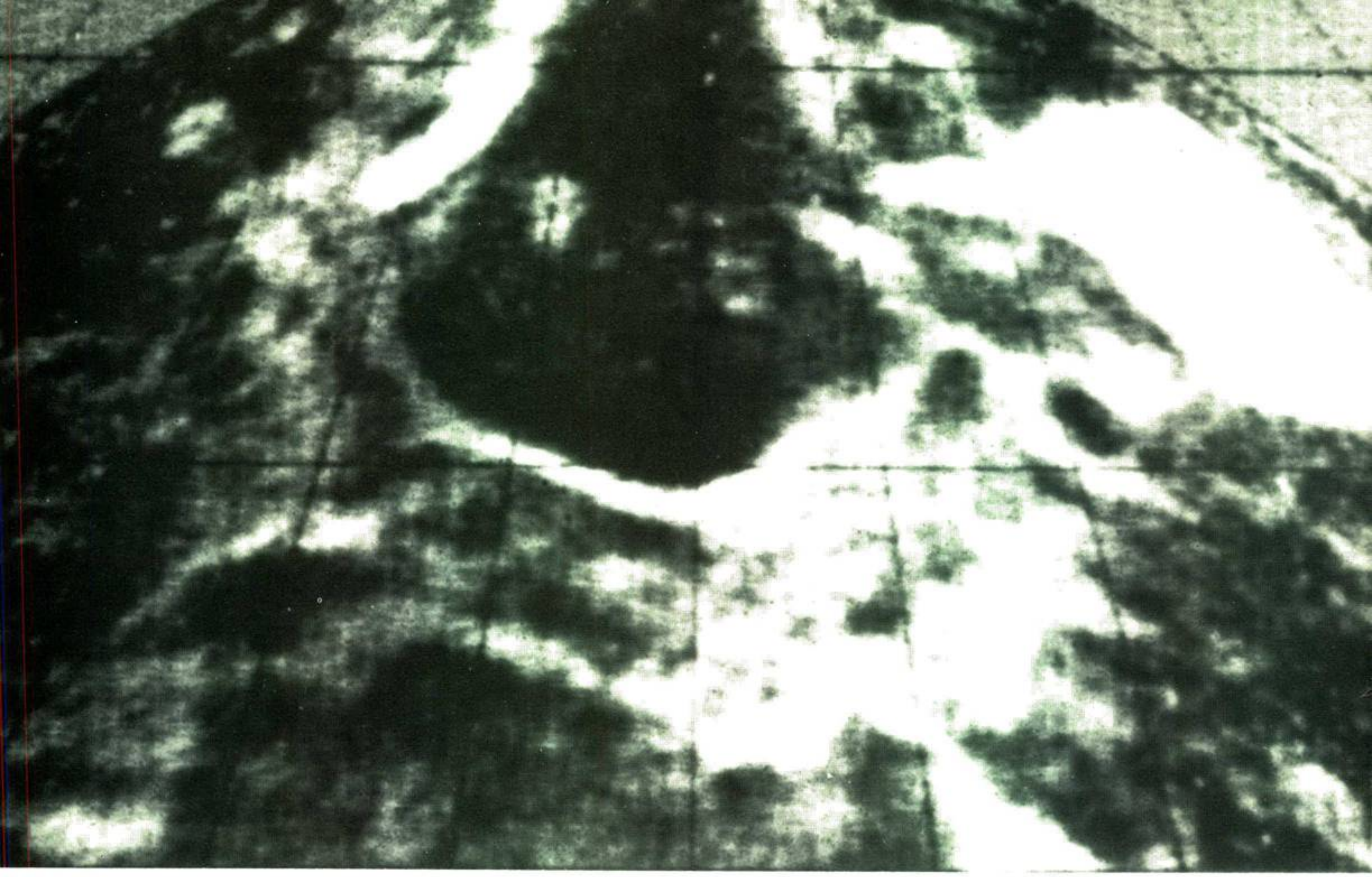
ESA's Spacelab

NASA photograph





After centuries of veiled mystery, the surface of the planet Venus has finally been revealed to us who live in this era of planetary exploration. In this artist's conception, a Venusian landscape is recreated from the data returned by robot probes. The eternal clouds, composed mainly of poisonous sulfuric acid, gleam with the scattered, sallow light of the hidden sun. In the thick but clear atmosphere below, 100 times more dense than Earth's, a broken, rocky vista stretches out before us. The temperature of 900 degrees Fahrenheit precludes the presence of any life forms, and rules out the romantic possibilities once entertained of vast oceans or lush tropical forests. Rather than a humid paradise, Venus has been revealed as a hellish vision of barrenness and sulfurous death! Artwork by David Egge.



The only way geologists are going to study large regions of Venus will be with radar. One of the early and still good images of the surface features is shown in this specially processed picture from the giant 1,000 foot radio telescope at Arecibo, Puerto Rico. (Radar aboard the Pioneer Venus orbiter will attempt to produce a better-resolved, synoptic view of Venus' surface features.) The basin shown here is about the size of Hudson's Bay and is probably an impact feature. NASA photograph.

probes. A classic example is provided by Mars. The attempts to detect life must in the final analysis be called indeterminate. The question was not settled by the strange and unexpected results, and new problems were raised. The chemistry of the Martian soil, it seems, is still far from being understood, and it may yet be possible that either a rudimentary form of life exists on Mars somewhere else, or in a form the life detection experiments couldn't catch. Another mission is needed — especially one designed to study the composition and chemistry of Martian soil — preferably by a lander with the capability to move about.

Mercury remains quite unstudied as yet. Only about half of its cratered, moonlike surface has been mapped. Much is not understood about the effects of its unique rotation on the evolution of its surface. A Mercury orbiter, capable of mapping the entire planet and studying it throughout a full rotation/revolution cycle, would be highly desirable. A lander could also return much useful information about the composition of surface materials subject to extreme temperature variations.

Other aspects of the solar system lie hidden in ignorance. Comets still present great mysteries to astronomers. We need data to help discriminate between the many conflicting theories of their origin and composition. The possibility still exists for a robot mission to Halley's comet upon its expected return in 1986 — but time is rapidly running out. Because of financial pressure, NASA has already reluctantly scrapped plans for a close encounter mission to Halley's comet. The problem is that Halley's comet circles the sun in a retrograde direction, and an elaborate propulsion system would be necessary to enable a trajectory match. Instead, NASA now proposes a flyby, with a probe-drop into the comet's tail. The primary craft would then continue on for an encounter with comet Tempel 2 three years later. Comet Tempel 2 orbits the sun once every five years, in the same direction as Earth. Such a mission could settle many of the riddles comets pose, and even perhaps provide important clues about the origin of the solar sysem. Because comets descend into the inner solar system from far outside the orbit of Pluto, a cometary mission would provide a unique opportunity to sample material which *spends most of its time* in the environment of interstellar space. But NASA's proposal has not yet been approved.

Space Policy Debate

NASA, having recently celebrated its 20th anniversary, now looks forward to an uncertain future. Present programs have been cut back to a minimum, and there's little hope of funding new ones. As one space scientist recently put it, "NASA's run out of places to save money; they've been paring budgets for 10 years, and now they've run out of places to pare." The next step can only be the wholesale cancellation of programs.

But the future of the United States' role in space is fast becoming a matter of major public debate. The White House had been under pressure for some time to articulate a clear space policy to govern this country's involvement in space science and technology for the coming decade; the policy statement finally appeared last fall, but has since been subject to severe criticism in both Congress and the press.

In the area of space science and exploration, President Carter's policy calls for the continuation of "a vigorous program of planetary exploration." The goal set for the years ahead is "to continue the reconnaissance of the outer planets and to conduct more detailed exploration of Saturn, its moons and its rings; to continue comparative studies of the neighboring planets, Venus and Mars; and to conduct reconnaissance of comets and asteroids."

While that may sound promising, look a bit closer at what is *not* said. As a number of critics have pointed out, no specific goals have been set, and a significant qualification was included: "The United States' priorities at any given time will depend on the promise of the science, the availability of the particular technology and the budgetary situation."

Critics have responded that the presidential program has "fine words, but no music." Senator Harrison Schmitt (R-N.M.), a former astronaut who has walked on the moon and now sits in the U.S. Senate, charged that "rather than exerting the leadership that the American people and the world expect, Carter has continued, and appears on the verge of, accelerating the policies of retrenchment begun by [President] Nixon."

There is no doubt that President Carter's program is cautious and conservative. In fact, his stated policy explicitly rules out as neither feasible nor necessary "high-challenge space engineering initiative[s] comparable to Apollo." The White House policy goes on to say that "as the resources and manpower requirements for shuttle development phase down, we will have the flexibility to give greater attention to new space applications and exploration, continue programs at present levels or contract them."

But this approach, despite the commitment to vaguely worded, non-specific goals of solar system exploration, may well mean the end of America's deep space missions. These missions simply don't provide the kind of flexibility looked for in the policy. Planetary and solar system probes cannot be funded on a year-by-year basis, and to initiate a mission is to commit a budgetary expenditure over a number of years — starting long before the actual launch and following up after the robot ship has passed its target(s). Because of the necessity of planning for "launch windows" and the inexorability of trajectory and encounter, deep space missions cannot be subjected to the options of delay, postponement and budgetary slow-up. A major mission to the outer planets, for example, involves an inflexible minimum expenditure over a period of perhaps 10 years during which the amount budgeted for any particular year can't be reduced once the program is under way without scrapping the entire program. In other words, major exploratory missions are marked by a significant lack of just the kind of budgetary flexibility the President is seeking. The end result will be a number of short-term, Earth-orbital programs mounted to appease space advocates, but which can be easily started or canceled for any particular fiscal year. Sadly, this seems to be the President's goal.

Whether or not he will get his way is less certain. Already a number of bills providing for stronger and more specific goals have been submitted to Congress. Two of the more important are those of Senator Schmitt and Senator Adlai E. Stevenson III (D-Ill.). The Schmitt bill specifically calls for manned exploration of Mars and Venus in conjunction with permanent bases on the moon and Mars. Development of such a capability is a goal to be reached by the year 2010.

We hope that these bills will at least bring the whole subject of space science and exploration out of government bureaucracy and into the public forum. This would be the most productive approach toward developing a truly comprehensive and clear space policy. The President's policy as it stands is too lacking in scientific, industrial and popular input to be a realistic basis for this country's future in space.

—The Editors

What You Can Do About the Future

Congress will soon be considering a number of bills which could provide for a strong United States space program in the coming years. It is important that those who favor a vigorous approach to space science and exploration make their views known to their senators and congressmen. Members of Congress do indeed listen to their constituents, and will be glad to hear from you.

Although all members of Congress eventually vote on legislation, the exact form of the bills presented is worked out in various committees. Proposals may be modified or even killed in committee, and thus may never reach the Congress as a whole for consideration. Thus, committees exercise a great deal of power over what actually goes into the final bills on subjects under their authority.

The committees which deal with bills pertaining to space science and exploration are, in the Senate, the **Senate Aeronautical and Space Sciences Committee** and the **Senate Appropriations Subcommittee on HUD-Independent Agencies**, and in the House, the **House Committee on Science and Technology**, the **House Science and Technology Subcommittee on Space Science and Applications**, and the **House Appropriations Subcommittee on HUD-Independent Agencies**. If any of your representatives sit on any of these committees, it is especially important that they know your stand on issues of space science and exploration. Your local library will be able to tell you what committees and subcommittees your congressmen and senators sit on.

Letters to members of the Senate are addressed as follows:

The Honorable Senator John Doe
New Senate Office Building
Washington, DC 20510

For members of the House of Representatives, the following example is appropriate:

The Honorable John Smith
U.S. House of Representatives
Washington, DC 20515

Be brief, courteous, and to the point. State your opinion clearly and concisely, and be sure to thank your representative for considering your position. It is especially important that you identify yourself as a constituent and a voter!

Asteroids, too, are outstanding puzzles. Recent discoveries indicate that the asteroids, once cursed as "vermin of the skies" for streaking — unwanted — across so many photographic plates, may soon become subjects of intense astronomical and scientific interest. Already it seems likely that at least one asteroid, Herculina, has a satellite of its own, and a recent discovery indicates that two asteroids may have fused to become a single, dumbbell-shaped body (see "Hektor — A Strange Asteroid?" on page 62). The composition of the asteroids may one day prove very important to Earth, if the feasibility of asteroid mining becomes a reality (see "Asteroid Mining," November 1978).

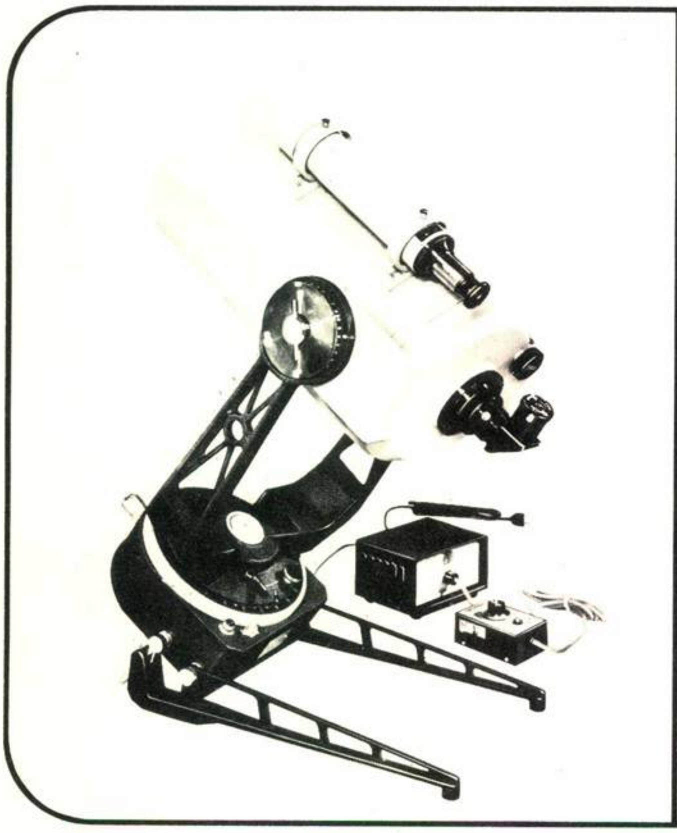
The solar system is a vast place, and its exploration will take centuries. This exploration, beyond doubt one of the greatest human endeavors of all time, has barely begun. Venus and Jupiter are the centers of attention right now, though the moon, Mars and Mercury have each had their time in the limelight. Later this year when the first probe reaches the planet Saturn, the media will be full of exciting news about the sixth planet. The possibilities and potential for future missions are enormous, but lead times for planning and execution are large. When the present missions have been completed, there may be quite a gap during which unsolved problems and unanswered questions swirl like gadflies to torment us. While little is known for sure about the Russian program's future, it must be said that things don't look promising in the United States. National commitment seems to be waning quickly. What's happened to the explorer spirit in this country?

Though beyond the financial capabilities of private institutions and industry — as is much else in modern scientific research — deep space missions cost only a tiny fraction of typical governmental programs. The complaint is often heard that until we eliminate poverty, we shouldn't be spending on space. There are at least three flaws in this false argument: First, the Department of Health, Education and Welfare (HEW) is presently spending NASA's entire annual budget every 8-1/2 days. You could give all of NASA's money to HEW and the impact on social welfare programs would be infinitesimal. Second, NASA itself is an employer, both directly and indirectly through contracts. Without NASA, many people would be out of jobs. The long-term social cost of having large numbers of highly-skilled people out of work is surely greater for the nation than keeping them productively employed. And third, no one is proposing that poverty programs be raided to fund deep space missions. Somehow, the impression is given that there will be *either* social welfare programs *or* space exploration. Nonsense! Why not both? If societies are judged by their contributions to knowledge as well as their standards of living, we would do well to push both vigorously!

What's coming next? That's up to *you*, the citizens of this country.

Performance is the First Reason You're Proud to Own a Criterion

In telescopes, "excellence is as excellence does." Our Criterion instruments, with unsurpassed optics, rank among the world's most widely praised, because they perform brilliantly, reliably and with satin-smooth, effortless ease. The more demanding the conditions of use, the more you appreciate the ability of your Criterion to deliver exciting results. Whichever advanced design telescope you select, you get a superbly engineered instrument, guaranteed unconditionally. When you compare the pleasantly surprising prices you find further reason to choose Criterion. Please note that they are not "base" prices, but include everything described AT NO EXTRA COST. Only Criterion's leadership in efficient, modern precision production makes these prices possible.



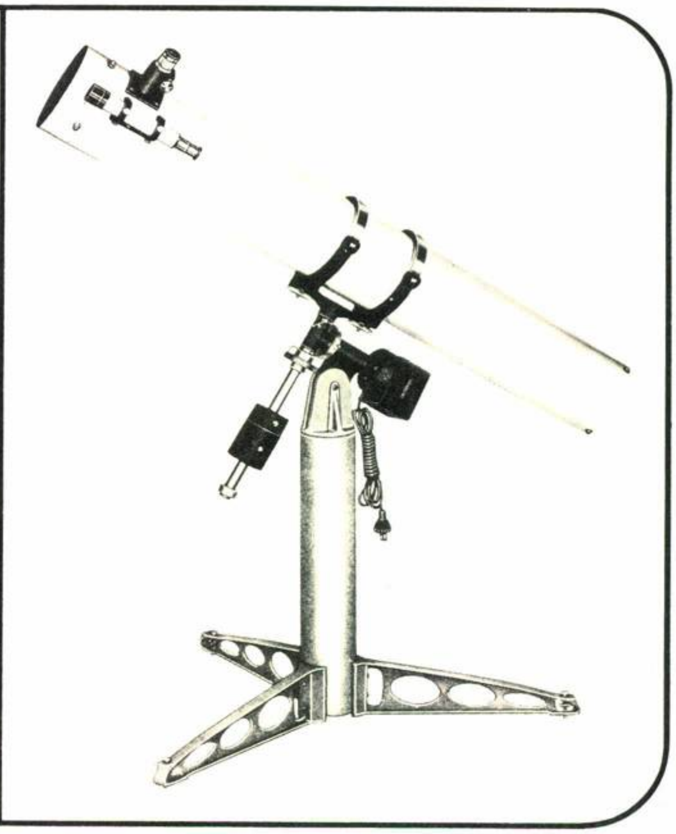
Dynamax® 8 8-Inch Schmidt-Cassegrain

For Spectacular Results—Effortlessly.
Extra Features Without Extra Price.

This "never before" telescope created by Criterion gives you Schmidt-Cassegrain advantages at their best: full 8" aperture, wide field, with flawless resolution, yet weighs only 30 pounds for one-hand portability! It offers unprecedented versatility for viewing, superb telephotography, terrestrial uses, or technical applications. The exquisite optics, combined with super-precise electric drive plus variable drive corrector, combine to insure unsurpassed, unequalled ease of use because the extra features so necessary for superior results are designed-in and built-in... and INCLUDED in the price! ☐ AC, DC, and manual drives (variable, not just solar). You can easily dial in lunar, solar, sidereal, planetary etc. rates while observing for extra long monitoring. ☐ Large 8x50 finderscope has micrometer screw focusing ☐ Toggle switch with pilot light ☐ Engraved setting circles, observable from viewing position ☐ 3 eyepieces included ☐ Star diagonal, latitude adjusters, photo and telextender adaptors, and custom, fitted case. Ready for Total Performance with nothing else to buy!

As described, complete. FOB Hartford, Conn.
Shipping wt. 65 lbs. Express charges collect.

$875



Dynascope® RV-6 6-Inch Newtonian

For Exciting Viewing, Superb Value.
Price Includes Built-In,
Precision Electric Drive!

Professionals and astute amateurs and school or college users by the thousands know the breathtaking performance, this pace-setting telescope achieves. ☐ Exquisite optical system includes f8 parabolic aluminized mirror, guaranteed to reach all theoretical limits of resolution and definition ☐ Highly accurate Electric Drive uses regular AC, has smooth, self-acting clutch, permits manual operation ☐ Two 1¼" eyepieces, 70X and 140X, included. (others available) ☐ Highly stable equatorial mount with solid tripod, adjusts easily for any latitude ☐ Engraved setting circles for both right ascension and declination ☐ Tube rotates for adding cameras and comfortable viewing Easy, quick portability ☐ Smooth, brass rack-and-pinion focusing ☐ Handsome, white 50" Bakelite tube maintains perfect collimation ☐ 6x30 finderscope ☐ Fine workmanship throughout.

As described, complete.
FOB Hartford, Conn. Shipping wt. 77 lbs.
Express charges collect, $15 crating charge.

$249.95

Prompt shipment on both models. If you wish, phone us for delivery date.
To place your order, or request literature, write or call:

Criterion Manufacturing Company

Dept.CAS-75 620 Oakwood Ave., W. Hartford, Conn. 06110/Phone: (203) 247-1696
In New York, Robert T. Little, Eastern Sales Manager (212) 834-1888

When the sky's the limit.

The Ad Astra telescope.

It's a quality product. Superb craftsmanship is assured. Ad Astra is a Division of Kimball International, Inc., one of the largest makers of keyboard instruments in the world, and makers of fine home and office furniture.

The Ad Astra can be used as a telescope or a telephoto lens; the Ad Astra is a natural for terrestrial or celestial applications. For daytime observing. Or nighttime.

See athletic events or lunar craters. Enjoy nature studies or globular and open star clusters. Or use the Ad Astra for high-quality photographic work.

Maksutov Cassegrain optical system.

The Ad Astra features the superb Maksutov Cassegrain optical system. It provides sharp, crisp images from the center to the edge of the field of view. Excellent telescope performance is assured with no loss of clarity.

Mail the coupon today.

For more information on the Ad Astra telescope, or to buy now, fill out the coupon below and mail it today.

( ) I wish to order now. Please send me:
  ( ) Ad Astra III, $359.95
  ( ) Ad Astra III AR, $399.95

Charge my Visa® card number ______________ or
Master Charge® card number ______________

( ) Enclosed is a check or money order.
( ) Please send me more information on the Ad Astra Telescopes.

Name ______________________________
Address ____________________________
City ______________ State ________ Zip ________

✦ ✦ ✦ ✦
ad astra
TELESCOPE COMPANY
PRECISION OPTICS
Phoenix, Arizona 85004
14 East Pierce Street
602 258-3009
A Division of Kimball International, Inc.

VISA

WE HONOR
master charge
THE INTERBANK CARD

Features, features and more features.

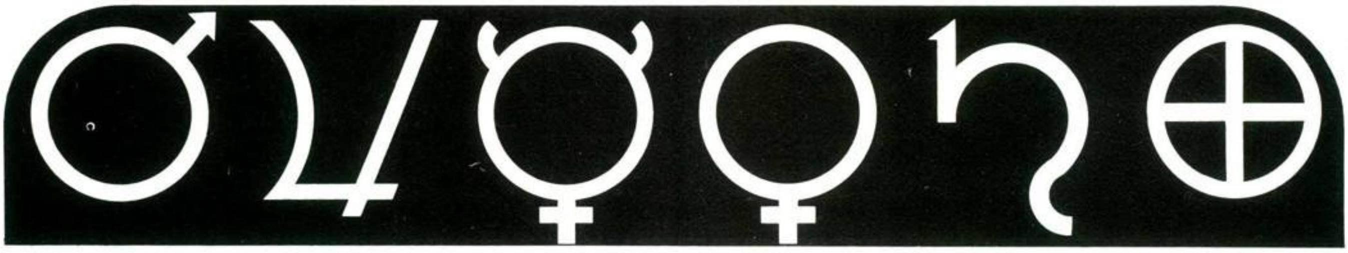
This highly versatile optical instrument focuses fast. The collar has special threading. So you can go from 8′ to infinity in just 2½ turns.

The Ad Astra withstands temperatures ranging from minus 25° to 120°. The focal length is 760 mm. and the aperture is 78 mm. (3.07″). The focal ratio is f:9.75. The telephoto lens has 15 power over standard 50 mm. lens. The magnification range of the telescope is 30 to 300 power.

Optional equipment: Equatorial Mount. 6 x 30 Finder Scope. Camera Adapter.

Ad Astra III with
6 x 30 Finder Scope
and Equatorial Mount.

Ad Astra III AR
with enhanced coatings and "Quick Release" feature, for camera adapter (camera not included).



Focus on the Outer Planets

The highlights of this month are the gas giant planets, Saturn and Jupiter: Saturn comes to opposition, and we'll tell you how to watch for a jovian moon's emergence from total eclipse! In addition, Mercury puts in a brief appearance to help cheer these shorter nights of March.

Mercury

As the month begins, you'll find Mercury in the evening sky. On the 8th, it'll reach greatest eastern elongation (at 01^h00^m UT), being then 18° from the Sun. On the same date, it'll be at maximum elevation over your western horizon — 11 to 12° high half an hour after sunset. The brightness of the 7.3 arc second disk will then be -0.1 magnitude.

Because the planet passes through perihelion (closest approach to the Sun) on the 4th, it's moving more swiftly than average. This evening apparition is relatively favorable in spite of both the small angular separation from the sun and the apparition's short duration, so don't hesitate to be out and looking for it! By the 24th, Mercury will be at inferior conjunction (between us and the Sun), and thereafter it'll be moving into the morning sky. (Check page 32 of the December issue for a diagram of Mercury's motions.)

Venus

Venus continues its long downward slide in altitude, while maintaining a steady northward progress in azimuth. On the 15th, look for it at magnitude -3.6, far overpowering the dim stars of its background constellation, Capricornus.

Venus is now gibbous in phase, and its telescopic apparent size will range from 17.1 seconds of arc on the 1st down to 14.1 seconds by the 31st. Over the same time period, its phase will increase from 67% lit to 77%. The apparent disk is rounding out as the planet moves away from us, and we are seeing more and more of the sunlit hemisphere.

On the 4th, Venus will be just one astronomical unit (93 million miles, 150 million km) from Earth. (There's a diagram of Venus' motion in the December issue, on page 32.)

Earth

Spring begins at 05^h22^m UT on the 21st, when the Sun crosses the equator into the northern celestial hemisphere.

Moon

There's a not-very-favorable occultation of Aldebaran on the 5th,

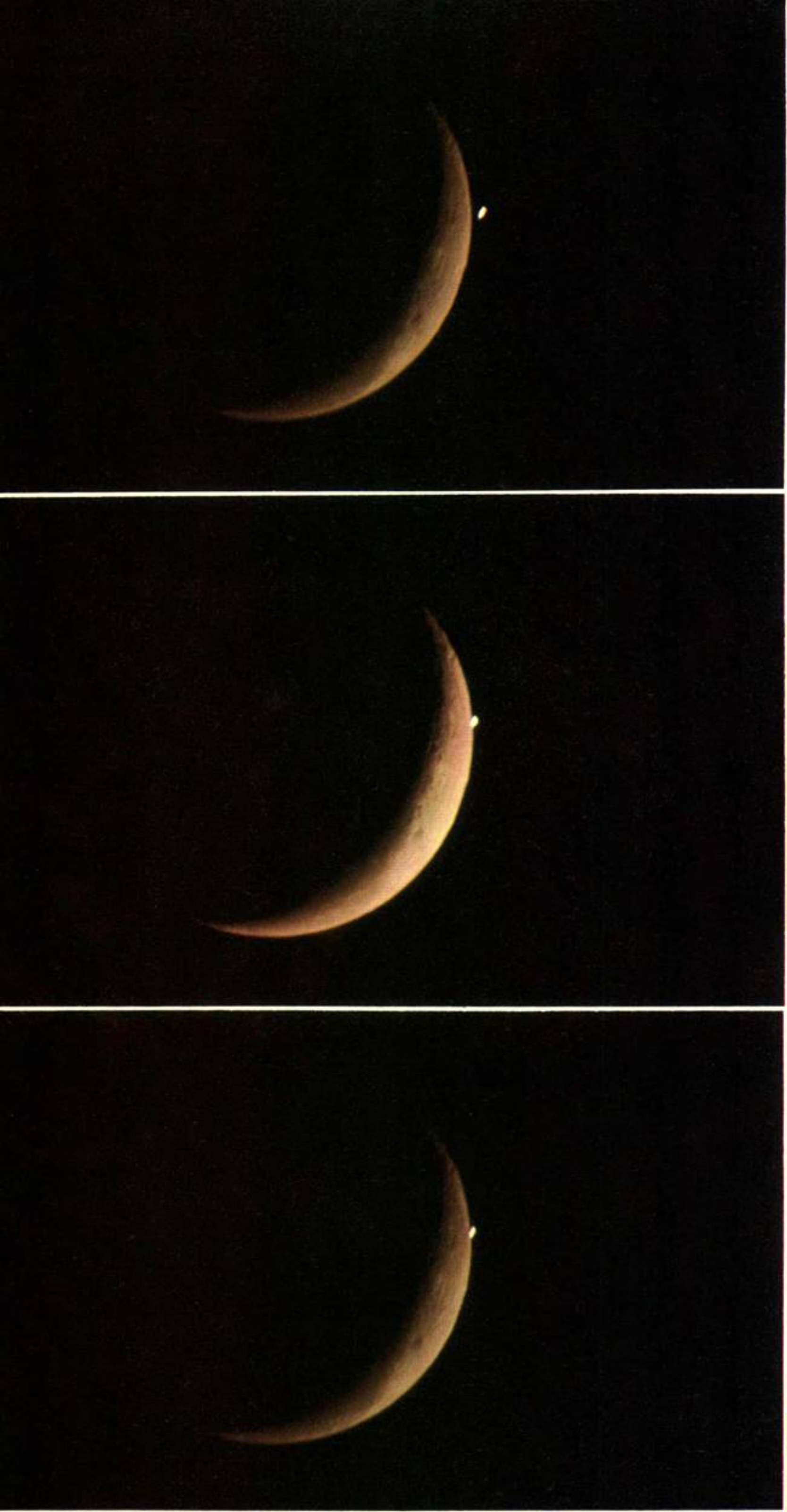
Upcoming Events — April

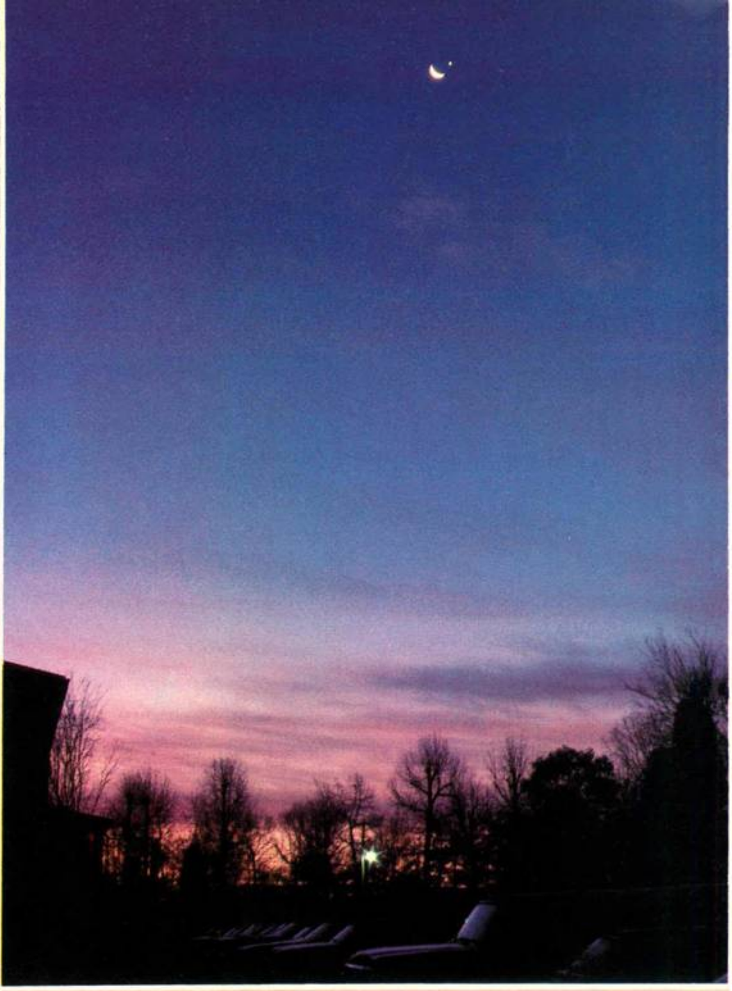
4	First Quarter Moon
5	Jupiter 5° north of Moon
6	Moon at apogee
8	Pluto at opposition
12	Full Moon
19	Last Quarter Moon
21	Mercury at greatest western elongation
22	Lyrid meteors
24	Occultation of Mercury
26	New Moon
29	Occultation of Aldebaran

April promises to be a busy one for Mercury watchers! The elongation on the 21st is one of the least favorable ones, but it's worth trying for anyway. The occultation on the 24th will be a sight to catch for observers east of the Rockies. Details next month.

The Lyrids are a smallish meteor shower: The usual hourly rate is about 15. In addition, a Moon past last quarter will light the skies somewhat.

The Aldebaran occultation will be visible for most of the country and Canada, except for the eastern parts of each.





The December 26th occultation produced a flood of photo submissions and observers' reports! Here we've chosen some of the best photos, but if yours isn't among them, don't be too upset. We had far more excellent ones than we could possibly run. Edward Martin of Walton, Kentucky took the sequence at left through a 6-inch f/8 reflector on Ektachrome 64 slide film. The large brightness difference between the Moon and Venus is apparent. The photo above shows what the occultation looked like for most viewers after Venus' reappearance. Photo by Randy Finch of Florence, Alabama. He used a 1 second exposure at f/8 on Ektachrome 200 with a 50 mm lens. Below: viewers in the west saw Venus reappearing in a dark sky, while those in the east could only see it well into dawn or after sunrise. Andy Barnes and Stephen Van Duine of Spring Valley, California used a 20 second exposure on Kodacolor II (ASA 100) at the prime focus of a 6-inch f/5 homemade telescope.

The early morning sun strikes the east-facing slopes in the region around Copernicus, bringing out the surface relief. Between Copernicus and Eratosthenes (to the lower left) lies the ruined crater Stadius and its chain of craterlets. The photo was taken with a 14 inch Schmidt-Cassegrain on ASA 64 film, using a two second exposure during excellent seeing. Photograph by James K. Rouse.

and only those who are in the southern half of California will be in a position to see it. Even so, for them the altitude of the Moon will be low at the time of disappearance (08^h08^m UT).

Later in the month, at the time of full moon, there'll be a partial eclipse of the Moon, but only the extreme northeastern part of North America will see it. The reason for this is that the Moon won't yet have risen for the rest of the continent. At mid-eclipse (seen by Europe and western Asia), 86% of the Moon will be in the Earth's shadow.

First quarter: March 5th, at 16^h23^m UT, in Taurus. Full moon: March 13th, at 21^h14^m UT, in Leo. Last quarter: March 21st, at 11^h22^m, in Sagittarius. New moon: March 28th, at 02^h59^m UT, in Cetus.

Mars

Tiny Mars will be growing slowly in apparent size over the coming months as Earth overtakes it in its orbit, but there's a long way to go until Mars is much more than a little orange blob in your telescope. Mars' size this month averages only four arc seconds — hardly anything at all! Try looking for the +1.4 magnitude point of light *very* low in the southeast just before sunrise.

Asteroids

Three of the four brightest asteroids are not really visible this month as they are either just past conjunction with the sun or just before it.

Ceres was in conjunction on February 18, Vesta on February 24, and Juno comes up to conjunction on the 22nd of this month. Only Pallas offers you a chance, however slim: You'll find it on the 15th in R.A. 20^h40^m, Dec. +5°59′57″ (1950 coordinates), at magnitude 10.8 in southern Delphinus.

Universal Time

Astronomers the world over use an unambiguous system of time reckoning based on a 24 hour clock, called Universal Time (UT). Times given in Sky Almanac are in UT unless noted otherwise. To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska and Hawaii, 10. For example, if an event is to happen at 03:00 UT on Jan. 2, then the time in EST would be 10 p.m. Jan. 1. Likewise, 03:00 UT on March 5 becomes, in PST, 7 p.m. on March 4.

Jupiter

All eyes in the astronomical world are turned on Jupiter this month as the first of two Voyager spacecraft makes its passage by the immense planet! (See this month's lead article.)

Still in Cancer, Jupiter will cease its westward motion on the 26th. At that time it'll be about a degree or so to the south-southwest of Mu (μ) Cancri, a 5.4 magnitude star.

Though it may not be immediately apparent, Jupiter is now slowly dimming as we move away from it. Over the course of the month, the distance grows from 4.49 AUs to 4.88. This corresponds to an increase of 36 million miles (or 59 million km). As a result, its magnitude will drop from -2.1 to -1.8. The angular size of the planet will likewise decrease: from 41 seconds of arc to 37.6.

One of several fascinating aspects of the Galilean moons (the four brightest) is the way they disappear into, and reappear from, the shadow cast by Jupiter.

This month the reappearances are the most easily observed phenomena. Although all four of the bright moons can be seen to reappear out of the cone of Jupiter's shadow at one time or another, the inner two, Io and Europa, have conveniently timed events. (The outer two satellites have longer periods of revolution around Jupiter and the phenomena happen during daylight for North American observers.)

On the 4th at 01^h14^m UT, Io will reappear on the eastern side of the planet, about one Jupiter radius from the planet's disk. On the 5th, at 02^h37^m UT, Europa will do the same, but at a distance just less than twice Io's. Io again makes a reappearance on the 11th at 03^h09^m UT. Europa follows on the 12th at 05^h12^m UT. Your last two chances to spot Io reappearing this month come on the 18th and 27th at 05^h05^m and 01^h29^m

The domes and buildings of Cerro Tololo Observatory (Chile) stand out against the southwest skyline. At left is the 4-meter telescope's dome. Counterpointed by the red glow of night lights around the buildings, the zodiacal light gleams palely. Also seen are several stars' colors and the track of a tumbling satellite. Photograph by James Janesick.

UT, respectively. Any small telescope will show you these events; use a moderate power. Try it!

Saturn

On the first of the month Saturn arrives at opposition. (When a planet is in opposition, it's 180° away, or opposite, from the Sun in the sky; hence the term. Since they are opposite each other, the planet will rise over your eastern horizon as the Sun dips in the west.) Although Saturn will be rising around 6:00 p.m. local time, you'd do best to wait an hour or two and give it a chance to climb out of the smog near the horizon before you look for it.

Saturn is in southern Leo, and easy to pick out since it's at magnitude +0.5. Look for the "star" that's just below the lion's body, and which isn't on the Star Dome constellation chart.

Modest optical powers will normally reveal the rings to you, but this year we're seeing Saturn approximately in the plane of the rings, making them virtually disappear when looked for in small instruments. Accordingly, you'll probably need at least a six-inch or larger scope to catch sight of them. Over the month, the aspect of the rings will open up slightly, from 5.8 to 6.8°, but the effect won't likely be noticeable to you.

Titan, Saturn's brightest moon, will be at western elongation from the planet on the 3rd and 19th. Eastern elongations come on the 11th and 27th. Titan will be a magnitude 8.3 speck of light about four ring diameters away from the ball of the planet. Binoculars or a small telescope will be just enough to show Titan to you!

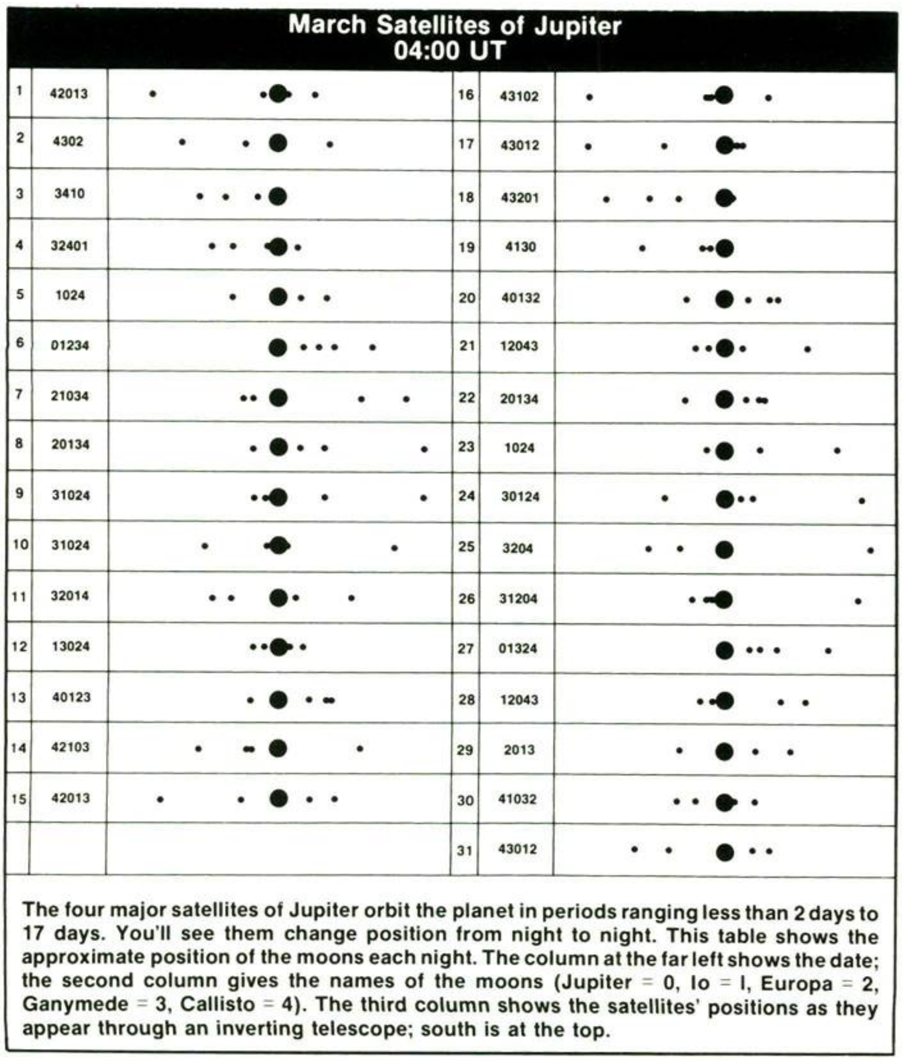
Uranus

Uranus can be found in the morning sky: Look for it in central Libra. The planet will be a +5.9 magnitude dot, 3.8 arc seconds across. You'll need a telescope to locate and identify it for certain!

Neptune

Even fainter and smaller is distant Neptune — since January the farthest planet from the Sun. You'll find the planet in southern Ophiuchus by looking for a 2.4 second of arc disk at the position given in Planet Finder. It'll be at magnitude +7.8.

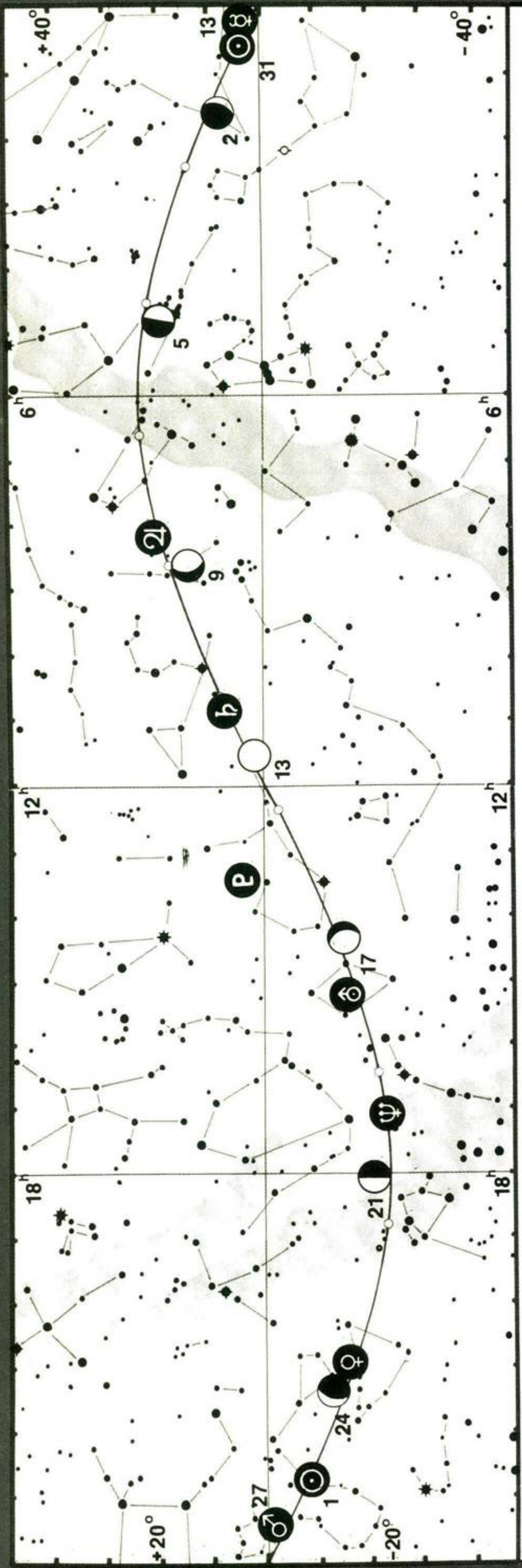
March Satellites of Jupiter
04:00 UT

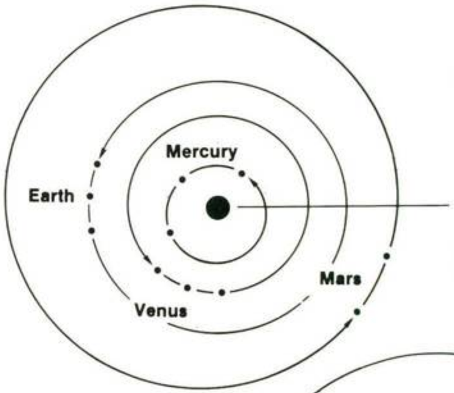


1	42013
2	4302
3	3410
4	32401
5	1024
6	01234
7	21034
8	20134
9	31024
10	31024
11	32014
12	13024
13	40123
14	42103
15	42013
16	43102
17	43012
18	43201
19	4130
20	40132
21	12043
22	20134
23	1024
24	30124
25	3204
26	31204
27	01324
28	12043
29	2013
30	41032
31	43012

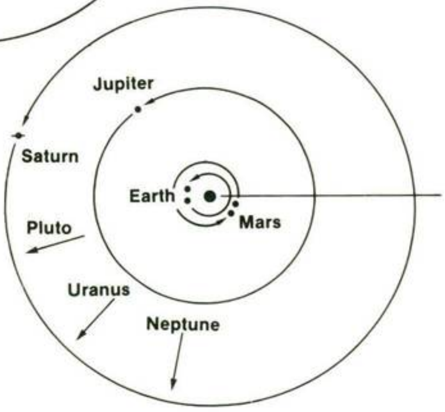
The four major satellites of Jupiter orbit the planet in periods ranging less than 2 days to 17 days. You'll see them change position from night to night. This table shows the approximate position of the moons each night. The column at the far left shows the date; the second column gives the names of the moons (Jupiter = 0, Io = I, Europa = 2, Ganymede = 3, Callisto = 4). The third column shows the satellites' positions as they appear through an inverting telescope; south is at the top.

Planet Finder


+40°
13
31
-40°
2
5
6h
6h
9
13
12h
12h
17
18h
18h
21
24
1
27
+20°
-20°

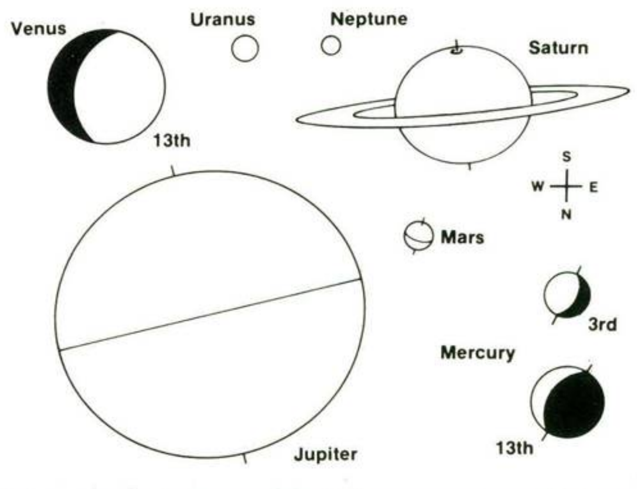

Mercury
Earth
Mars
Venus

The positions of Mercury, Venus, Earth and Mars in their orbits are shown for the beginning, middle and end of the month. (Mars for the beginning and end only). The vernal equinox is the line at right.

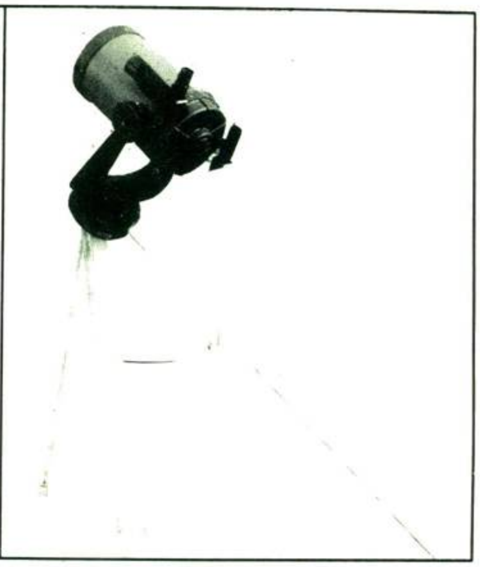

Jupiter
Saturn
Earth
Mars
Pluto
Uranus
Neptune

The orbits of Earth, Mars, Jupiter and Saturn are shown at right. Earth and Mars' positions are for the first and last of the month: Jupiter and Saturn for mid-month. The outermost planets' directions are indicated.

Planet	Date	R.A. (1979.3)	Dec.	Mag.	Dist. (AU)
Mercury ☿	1	$23^h43.3^m$	-01°31.6′	-0.8	1.11
	9	$0^h18.3^m$	4°14.9′	+0.1	0.89
	18	$0^h23.6^m$	6°20.9′	+1.7	0.68
Venus ♀	10	$20^h38.4^m$	-17°52.6′	-3.6	1.05
	30	$22^h13.2^m$	-11°41.6′	-3.5	1.19
Mars ♂	15	$22^h55.0^m$	-8°03.7′	+1.4	2.34
Jupiter ♃	15	$8^h06.0^m$	20°59.7′	-2.0	4.66
Saturn ♄	15	$10^h47.4^m$	9°54.2′	+0.5	8.37
Uranus ♅	15	$15^h14.1^m$	-17°38.1′	5.7	18.12
Neptune Ψ	15	$17^h19.0^m$	-21°41.0′	7.7	30.21
Pluto ♇	15	$13^h32.2^m$	9°22.5′	14.0	29.40


Venus
13th
Uranus
Neptune
Saturn
S
W
E
N
Mars
3rd
Mercury
13th
Jupiter

SUPER GIANT RICH-FIELD FINDER
Giant Rich-Field Finder on C-8.



C-8 on A NEW ISOSTATIC EQUATORIAL MOUNT with ACCESSORY TRAY

We continue to make the best better.

Every SUPER CLESTRON 8 we sell not only comes equipped with our FREE GIANT RICH FIELD SUPER FINDER but now can be supplied with our NEW ISOSTATIC EQUATORIAL MOUNT.

This sturdy, stiff, vibration-free, stable support folds up for compact storage. It has a simple one-hand latitude adjustment from 25-55 degrees and functions as both a wedge and a tripod. It needs no tools and can easily be fitted with a convenient accessory tray.

In addition with our Rich Field Finder Equipped Super Celestron 8, we still give you your choice of any three of our Custom Engineered accessories FREE such as Solar Skreen® and Cell, Polaris Pointer, Precision Polar Axis Finder, No Du Cap, Micro Drive, R.A. & Dec. Lights, Mini Mount or Fitted Case Liner.

Not only that, but we ship FREE in our own special custom made containers to better protect the fine optical performance. We test and collimate the scope and guarantee optical alignment for as long as you own your scope. No other dealer we know gives you these extras and offers this guarantee.

Get the full story on this NEW ISOSTATIC EQUATORIAL MOUNT and our GIANT RICH FIELD FINDER, a valuable aid to locating objects — the hardest part of our great hobby. Send a LARGE 8-1/2"x11" Self Addressed Stamped Envelope for any of the following:

- Our 24 Page Astronomical Catalog
- Tuthill's Twenty Two Telescope Tips
- Our Comet Award Program
- Tuthill's Maintenance Instructions for Celestrons
- Z-1000 Eyepiece Report
- Why Celestron — 18 Reasons
- Free Celestron Collimation Kit Celestron 8

FLORIDA DEMONSTRATIONS AVAILABLE

BANKAMERICARD

master charge
THE INTERBANK CARD

Master Charge, Visa and Bank Americard

Financing Available

MONEY-BACK GUARANTEE ON ALL PRODUCTS WE SELL

ROGER W. TUTHILL, INC.

Box 1086A, 11 Tanglewood Lane, Mountainside, N.J. 07092 Telephone 201-232-1786

STRAIGHT TALK ABOUT EYEPIECES

Of course no eyepieces are perfect in every respect BUT eyepieces are the final key to good telescope optical performance. We offer the following eyepiece choices:

Kellners $30 ea.
Orthoscopics $32 ea.
Erfles $39 ea.
Brandons $55 ea.
and
Clave´ Plössls $68 ea.
Clave´ & Dakin Barlows

These eyepieces span the viewing requirements of the casual observer to the most demanding professional. Write for a copy of an independent users report #Z- 1000 for a detailed discussion of the essential points of comparison on these critical elements contributing to your astronomical enjoyment and satisfaction.

ATTENTION CELESTRON 90 SPOTTING SCOPE OWNERS

A C-90 on a Tuthill Equatorial Fork Drive for Camera Tripods

- Ideal focal length for Solar Eclipse Photography
- Lightest weight equatorial mount available
- Stable solid worm drive
- Easy to mount — no drilling or tapping required
- Follows the sun effortlessly

TUTHILL DRIVE
ONLY — $174.

Attention Dynamax Owners

Custom Engineered Accessories for your scope to enhance its operation

- Finger-tip latitude adjuster for New Criterion field tripod.
- Put the famous locked triangle Celestron tripod and wedge under your scope.
- Velvet touch helical focuser-overcomes mirror image shift during focusing, when present.
- No Du*Caps reduce dewing to improve viewing.
- 7x50 right angle variable power finder - wider fields and brighter views. Takes standard eyepieces.
- Precision Polar Axis Finder makes lining up on the Celestial Pole a snap.
- Tele-Compressor reduces photographic time on deep sky objects.
- Solar Skreen* and Luna Shade* filters and Cells.
- C90 Omni-Axis mount.

AN ARRAY OF GREAT PRODUCTS
To Make Your Hobby More Enjoyable

THE STEREOOCULAR*
ON A CELESTRON® 8

Lets you look naturally and restfully with two eyes. Gives great views of moon and planets. Some even claim to see a 3-dimensional effect.

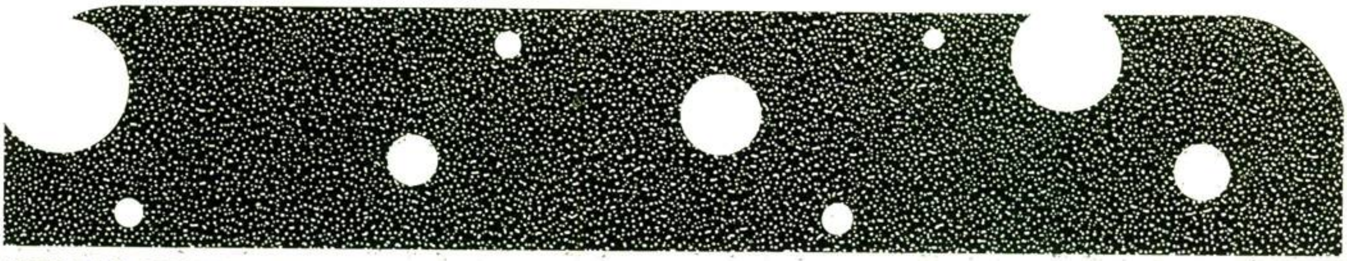
Fits 1-1/4″ drawtubes on refractors or Cassegrain-type scopes. Used with matched eyepieces. Two persons can use it at the same time. **Still only $279.**

CELESTIAL NAVIGATOR™

Read the pointing direction of your scope in large easy to read numerical digits, just like they do in the large observatories. Accurancy 1/4 deg in R.A. & 1/6 deg in Declination. Includes two optical shaft encoders and a nifty control console for entering star position. Easy to apply to Celestron scopes as well as Home built units and Observatory instruments.
From $437

CELESTIAL NAVIGATOR

ROGER W. TUTHILL, INC.
Box 1086A, 11 Tanglewood Lane, Mountainside, NJ 07092



STELLAR FRONTIERS

Planetary Nebulae, Part 1

How Stars Lose Their Cool

by
David Darling

Curious, remote and hauntingly beautiful, planetary nebulae are often spotlighted by the illustrators of astronomy texts and magazines. Their names — Helix, Dumbbell, Ring and Owl — trigger interest and imagination. Yet these seemingly familiar "planetaries" present enigma within enigma to the astrophysicist. They are much less understood than is commonly supposed, but as a key piece in the complex puzzle of stellar evolution, understanding them is vital.

In this first of a two-part series, we'll be dealing with the controversial origins of planetary nebulae, and with the fascinating early evolution of these objects. The second article will focus on the types of events taking place within mature nebulae, and on the overall galactic significance of the planetaries.

Take a mind's eye journey. You're standing on the fifth planet out from an old and dying star. In the fairly recent past, no more than a few million years ago, this star exhausted its main energy supply. To be exact, it finished converting all of the hydrogen nuclei within its core to helium by thermonuclear fusion. Young and middle-aged stars, like the sun, have a healthy supply of this core hydrogen, and can shine, apparently without change, for several billion years. Once that all-important, energy rich source is gone, however, changes in the star occur rapidly and are spectacular in nature.

Back to our alien sun. It is now very luminous, and its cool surface layers (at around 3,000 degrees Celsius) pulsate with a semiregular period of about 200 days. What events following hydrogen exhaustion in the core could have produced such a bloated unstable star? What mechanisms drive the pulsations, and provide the key to the ejection of a planetary nebula?

Of all thermonuclear fusion reactions, hydrogen to helium conversion occurs at the lowest temperature — around 15 million degrees Kelvin. Oddly enough, even with all the core hydrogen gone, our imaginary star continues to look pretty much the same to observers on Planet V. Light and heat still pour out from the surface with the same intensity, and life on the fifth planet continues essentially unchanged.

Astronomers there, however, worry about the condition of their sun. It has clearly begun to collapse! With the cessation of internal nuclear reactions, the star is now drawing the energy it radiates into space from a steady gravitational contraction of its material. Gravity is winning the battle of forces against thermal pressure (previously maintained by ongoing nuclear processes at the center). With no outward force to balance it, gravity is slowly but inexorably compressing the star.

Thermal pressure has lost in this battle, but gravity has still to win the war. Only in the case of the bizarre black hole does gravity ever succeed in finally overwhelming all resistance. Planet V's star, with a mass close to that of our own sun's, could never undergo such advanced gravitational collapse. So what prevents the relentless tug of gravity from squeezing the star out of sight? Answer: gravity itself!

By writing down some very basic equations of physics, and solving them for the case of a star such as the one described here, astrophysicists came up with a surprising fact. During the period in which the star is contracting, exactly half of the gravitational energy is lost by radiation from the surface. So what happens to the other half? It heats up the star.

Here, then, is the key to the next stage of the star's evolution. As gravity forces the whole star to heat up, the core, now almost pure helium, reaches higher and higher temperatures. It takes 100 million degrees to fuse helium though, and well before this, a "hydrogen burning" shell breaks away from the periphery of the core and starts to eat its way slowly outwards.

As hydrogen burning proceeds in the outward moving shell, the helium "ashes" produced pile onto the central core. Although fusion in the energy rich shell stops overall contraction of the star, gravity still has the upper hand in the dormant core, which continues to collapse.

A dramatic change is now imminent in the entire outward appearance of the star. A point is reached at which the helium core becomes so massive it can no longer support its own weight plus that of the overlying layers. Suddenly, the core begins to contract rapidly, while the surrounding hydrogen envelope greatly expands. Temperatures within the dense core hit 100 million degrees — the critical value at which helium fusion can occur!

Mass plays a key role in determining a star's evolutionary path. We needn't concern ourselves too much with detail here, except to note that with fairly low mass stars, like our sun, the onset of helium fusion in the core can be extremely rapid. Astrophysicists refer to this ultrafast, indeed explosive, core helium ignition as the "helium flash." The vast outpouring of radiation from the reactivated core pushes the overlying layers outward, at the same time cooling them. A red giant star is formed.

For a short period following its helium flash, Planet V's sun achieves a new stability. Steady contributions of energy are made by both the helium burning core and the outward moving hydrogen burning shell. But this can't last long. Helium, as a fusion fuel, is far less energy-rich than hydrogen. What's more, at the higher temperature needed for helium fusion, the helium is soon burned up. Just a few

The Helix nebula in Aquarius (NGC-7293) has the largest angular diameter of any planetary, covering an area 15 by 12 minutes of arc — nearly 1/4 the apparent size of the full moon! Not surprisingly, it is also one of the nearest, being less than 600 light-years distant. Photograph by Ben Mayer.

million years after the triggering of the helium flash, all that remains in the star's core is the chief fusion product of helium — the element carbon.

Now we are close to understanding the origin of the pulsations of our imaginary star, and of their probable link to the formation of planetary nebulae!

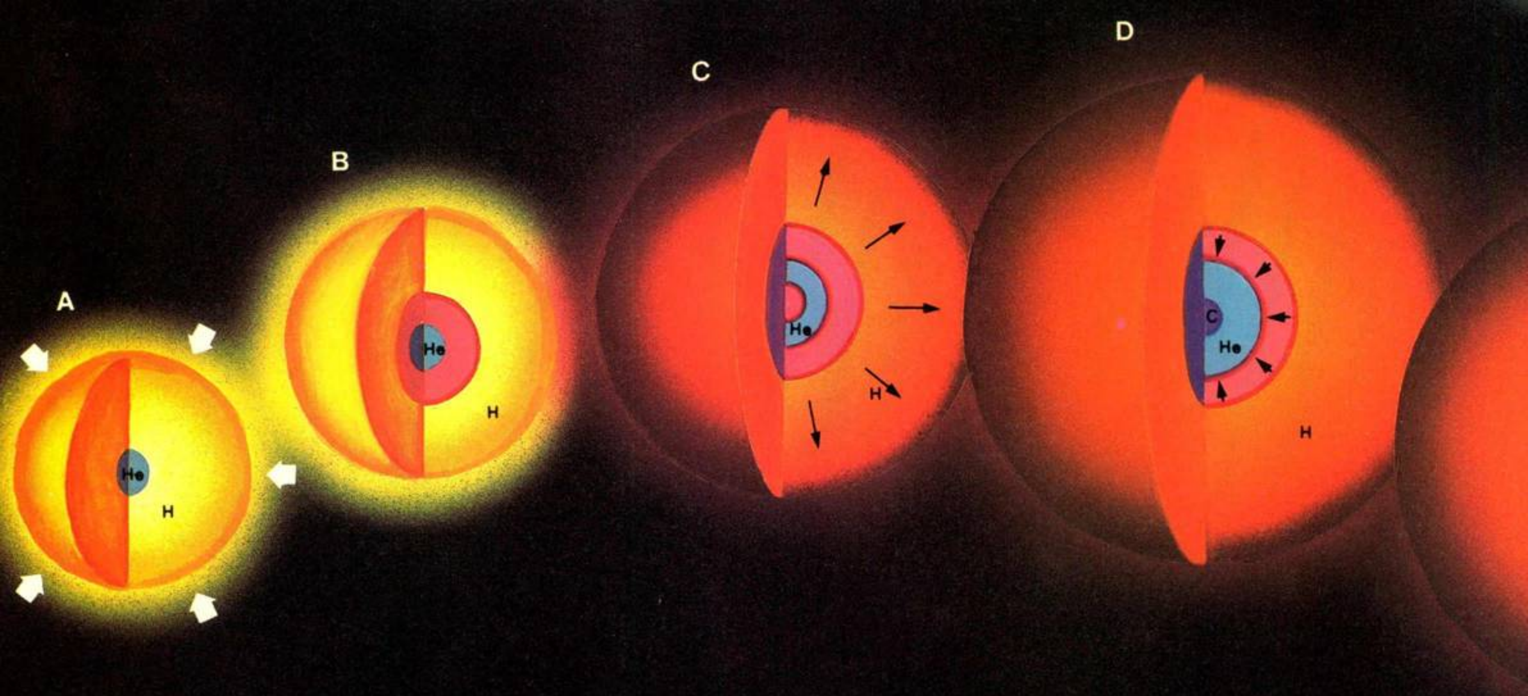
The hydrogen burning shell relentlessly continues its journey outwards from the center and the pressure generated by its energy release supports all of the overlying unburned hydrogen. But beneath the shell, the star matter is dormant; it has temporarily stopped releasing energy.

What comes next is virtually a repeat performance of the earlier phase of contraction. The carbon core gets more and more compressed — but so does the unburned helium layer outside it. Long before the core gets hot enough for carbon to start fusing, a helium burning shell forms at the core's outer edge.

Picture again the vast pulsating red giant dominating the skyline of Planet V. Its star with an inactive, though intensely hot carbon core. Outside the core is a helium layer at the inner edge of which is an outward-moving helium burning shell. Carbon ashes from this shell are dumped onto the growing core. Beyond the helium layer is a pulsating atmosphere of hydrogen at the inner edge of which is a hydrogen burning shell. Helium ashes from the hydrogen shell replenish the helium layer.

Why does the hydrogen layer pulsate? More to the point, why is a star at this stage of evolution — with two actively fusing shell sources — believed to be the progenitor of a planetary nebula?

One clue is that nuclear reactions are very fussy about temperature. Even the slightest increase in temperature has a big effect on the rate of fusion, and likewise, energy release. Think for a moment about the hydrogen burning shell. Small ripples in its temperature step up its energy release enormously. Because the shell gets hotter, it expands, lifting the overlying unburned hydrogen upwards. Expansion cools the shell again and these layers fall back to their previous position. This cycle occurs over and over, pretty regularly, causing the pulsations which are



The successive stages in the creation of a planetary nebula are shown schematically above. The sizes of the various layers and shells are not shown to scale, nor are the stages themselves — for example, the red giant star is vastly larger than the others! *A*: A star with a large helium core, no longer able to burn hydrogen into helium for energy, begins to contract and convert gravitational energy into heat. *B*: The temperature at the surface of the helium core becomes high enough to re-ignite the hydrogen, and a hydrogen burning shell forms around the core. *C*: Next, the enlarged helium core suddenly contracts and becomes hot enough to begin the process of helium fusion. This helium flash generates enough energy to expand greatly the outer layers of the star, which now becomes a red giant. *D*: The process begins to repeat in a different way as a new core forms, composed of the carbon ash of helium fusion. *E*: Similarly, the temperature rises high enough at the surface of the carbon core for a helium burning shell to ignite, further heating up and adding more carbon to the core. The outermost shell, composed of thin, relatively cool hydrogen, begins to pulsate. *F*: The pulsations become unstable, and the entire outer layer of the star is blown off in a massive explosion. *G*: Leaving a white dwarf star behind, the expanding shell of gas becomes visible to us as a new planetary nebula! Artwork by Thomas Schroeder.

visible from our imaginary Planet V.

For a number of reasons — some simple, some not — these pulsations may become unstable. Significantly, radiation pressure from within the star is steadily growing, as gravitational contraction heats up the core and its surroundings. Neutral atoms and minute grains of matter condensing out in the cool upper layers of the star get an additional outward boost from this pressure.

Finally, the pulsations rip open the star — the entire unburned hydrogen layer is flung into space! A planetary nebula, a rapidly expanding shell of gas, is born. These dynamic events, the complex interplay of forces and the subsequent mass loss, also mark the beginning of a star's death.

So far we've followed the advanced evolution of an imaginary star as seen from its fifth planet. Let's bring that a little nearer home. In another five billion years or so, put Jupiter in the place of Planet V and our sun in the place of the imaginary star! For a sun-sized star, maybe 1/5 of its total mass is lost during the ejection. Does this make our sun a cosmic celebrity — one of the few stars destined to end its days haloed by a splendid luminous cloud of gas? It might seem so from the apparent paucity of planetary nebulae. Only around a thousand are visible from Earth (compared to the total galactic star count of over 100 billion), and the nearest one is 1,000 light-years from here.

But let's get that in perspective. Planetaries may appear scarce, but on a stellar time scale they're very short-lived. The nebular gas cloud expands rapidly enough for it to completely dissipate within 100,000 years. All that remains then is a white dwarf star, slowly cooling as time goes on. Because planetaries are transient by nature, we wouldn't expect to see too many of them at any one time. Surprisingly, to maintain a constant figure of even 25,000 nebulae (a conservative estimate for the whole galaxy), it seems that about half of all the stars in the galaxy must at some stage eject mass by the process we described earlier. And the sun is almost certainly one of them.

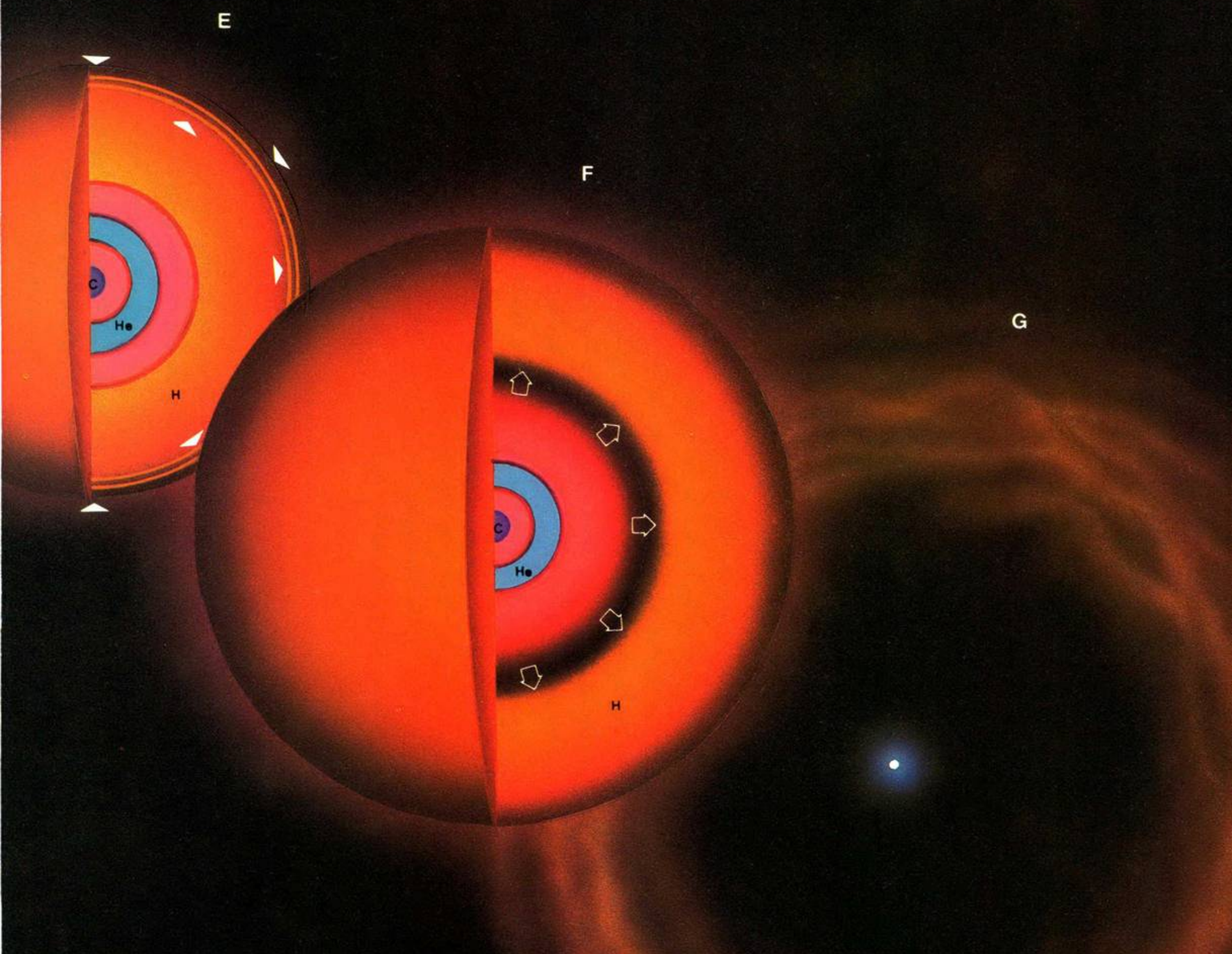
Now let's pick up our story from the time the hydrogen rich envelope of the old red giant is thrown into space. What's left of the star is little more than an intensely hot (around 200,000 degrees Celsius), dead core. Carbon is the main component, with a thin mantle of helium at the surface.

The young, compact gas cloud, on its one-way journey out from the parent star, has far to go before it rivals the size or beauty of mature planetaries like the Ring or Helix. To use ball park figures, even with a typical outward speed of 20 kilometers per second, it would take the gas around 15,000 years to get just one-tenth of a light-year from the central star. That's still a small object, and unless it were in our immediate stellar neighborhood, we would see no detailed structure.

Now another question. Why is a nebula visible at all? There's no nuclear fusion taking place, and by itself the nebular gas would be very cold, no more than a few degrees above absolute zero. Yet the familiar planetaries recorded on so many photographs are most definitely visible!

The central star, parent of the expanding nebula, still plays a key role in the future of its offspring. With its cool, tenuous outer layers gone, the remnant star is hardly more than an intensely hot, though inactive, core. At the surface of the exposed core, the temperature is at least 100,000 degrees and most of the radiation streaming outward lies in the far-ultraviolet region — high in frequency and, therefore, in energy. The ultraviolet radiation strips the outer electrons from the atoms of the nebular gas in a process called *ionization*. Generally, many types of atoms in a variety of ionization states coexist within the nebula. Upon recombination, as we'll see in the next article, electrons and different species of ions give rise to the complicated visible spectrum associated with planetaries.

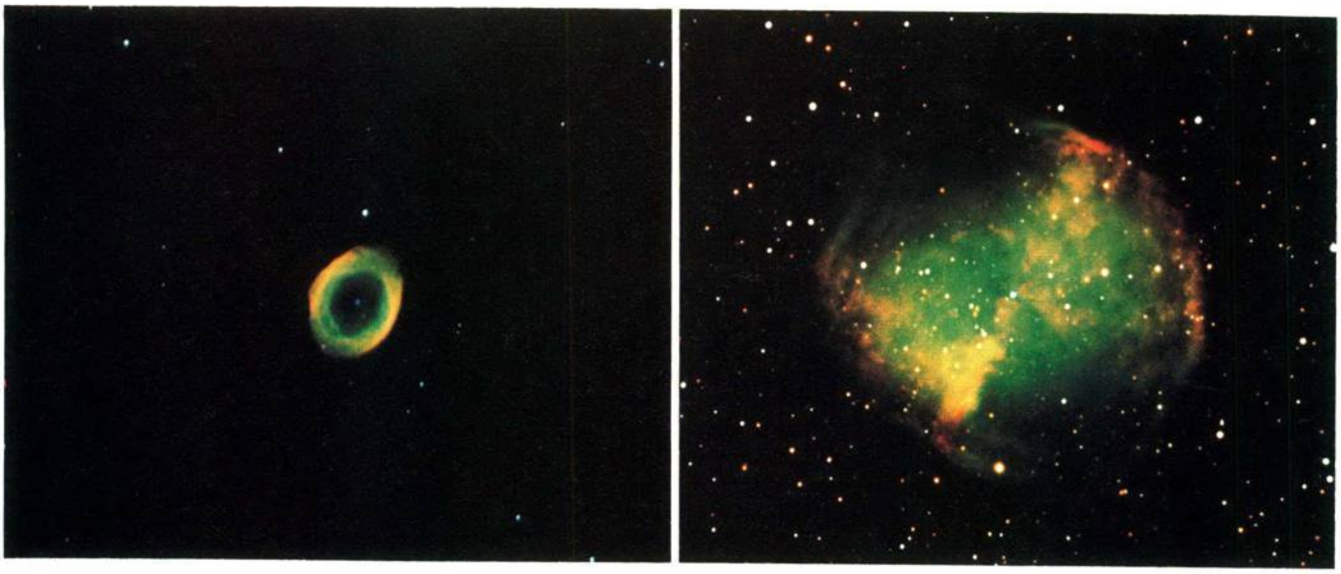
Now we're zooming in on one of the most controversial areas related to planetary nebulae. Looking at them as



a pretty well-defined class of objects, what's the most puzzling feature about them? Browse through past issues of **ASTRONOMY** or flick through the pages of a popular book on the subject and it will surely hit you. They are incredibly diverse in appearance! No two look exactly alike and for the most part they're a fascinating collection of rings, flattened rings, disks, helices, double shells, spirals and even more complex structures. Why this rich variety of form? Is there really an all-embracing evolutionary process which would allow for such variety, or is there a basic difference in the origins of the various types?

Here we find ourselves in exciting but poorly charted regions. Some theoretical work has been done on the early evolution of planetaries, but it's incomplete and patchy. What's clear is that a number of factors are at work shaping and molding the expanding nebular clouds as they leave their parent stars. Conditions immediately before ejection play their part. Is the star's rotation fast or slow? Is mass lost uniformly from the whole surface, or are the equatorial regions favored? Over what period of time does mass-loss occur — 1 year, 100 years, 1,000 years? Answers to these questions must vary widely from star to star, giving the first clue to structural diversity in planetaries.

Think of this scenario. Star A is similar in all aspects to Star B except that the rotation rate of A is considerably higher. Mass loss from A will be more from its equatorial regions, where the rotation speed greatly exceeds that at the poles. Star B's ejection is a much more uniform affair, and the whole stellar surface is involved when the nebula is thrown off. We don't need higher math to visualize the resultant planetary nebula in each case. Star A will have a toroidal nebula — a donut-shaped cloud of luminous gas which might appear as a ring, a flattened ring or a rounded rectangle, depending on the



These two photographs illustrate the great diversity of form seen in planetary nebulae. On the left, the familar Ring nebula in Lyra (M-57 or NGC-6720) exhibits a straightforward spherical shell, while (on the right) the Dumbbell nebula in Vulpecula (M-27 or NGC-6853) shows a far more complex structure. Photographs by Lick Observatory.

line of sight of the observer. (Experiment with your own donut and see!) Star B's nebula, a simple spherical shell, will look like a disk from wherever the observer views it.

Today it seems clear that at least some of the ringlike planetaries are really immense gas toroids in space. M-57 in Lyra, the familiar Ring nebula, is one of them — an expanding luminous donut projected on our sky as a conspicuously flattened ring.

Another 1,000 years have passed on planet V. Understanding the condition of their red pulsing sun, the inhabitants have constructed underground shelters across all their world. Astronomers, anticipating the star-tearing cataclysm wait with their instruments trained on the unstable star; satellites in orbit about the planet are readied for the time of . . . .

Explosion! One-fifth of the star races outwards, searing and destroying all remaining surface life on Planet V as it speeds past. Now many factors — stellar rotation is one of them — are playing their part in building new forms from the evolving gas cloud. How these factors are balanced for a particular star — the relative importance of stellar magnetism, rotation and radiation pressure, for instance — will determine much of the structural form of the nebula and how it will appear in maturity to observers in neighboring galactic space. Just how that star throws off its hydrogen atmosphere, how soon it can begin pumping high-energy ultraviolet into the young nebula and what stages it will pass through as it cools, stamps the mark of individuality on the evolving planetary. The past, present and future of a planetary nebula are inextricably bound up with the behavior of its central star. No two nebulae are alike, just as no two stars are exactly alike.

As we mentioned earlier, the events taking place during the actual ejection are not clear to us. According to some interesting new evidence, it may be that the central stars of planetary nebulae lose their hydrogen envelopes only very gradually — over a period of several thousand years. Then, instead of a sudden explosion in which the entire hydrogen atmosphere is blown away, the process may be more on the scale of an intense stellar wind. A curious infrared source in Leo, with the distinguished title of IRC +10216, supports this idea. Dust and molecules in the cool Leo object seem to be forming an expanding shell around a brightening central star. Later, when the star's core is fully exposed, the intense ultraviolet pouring from its surface will ionize the nebula and so make it visible.

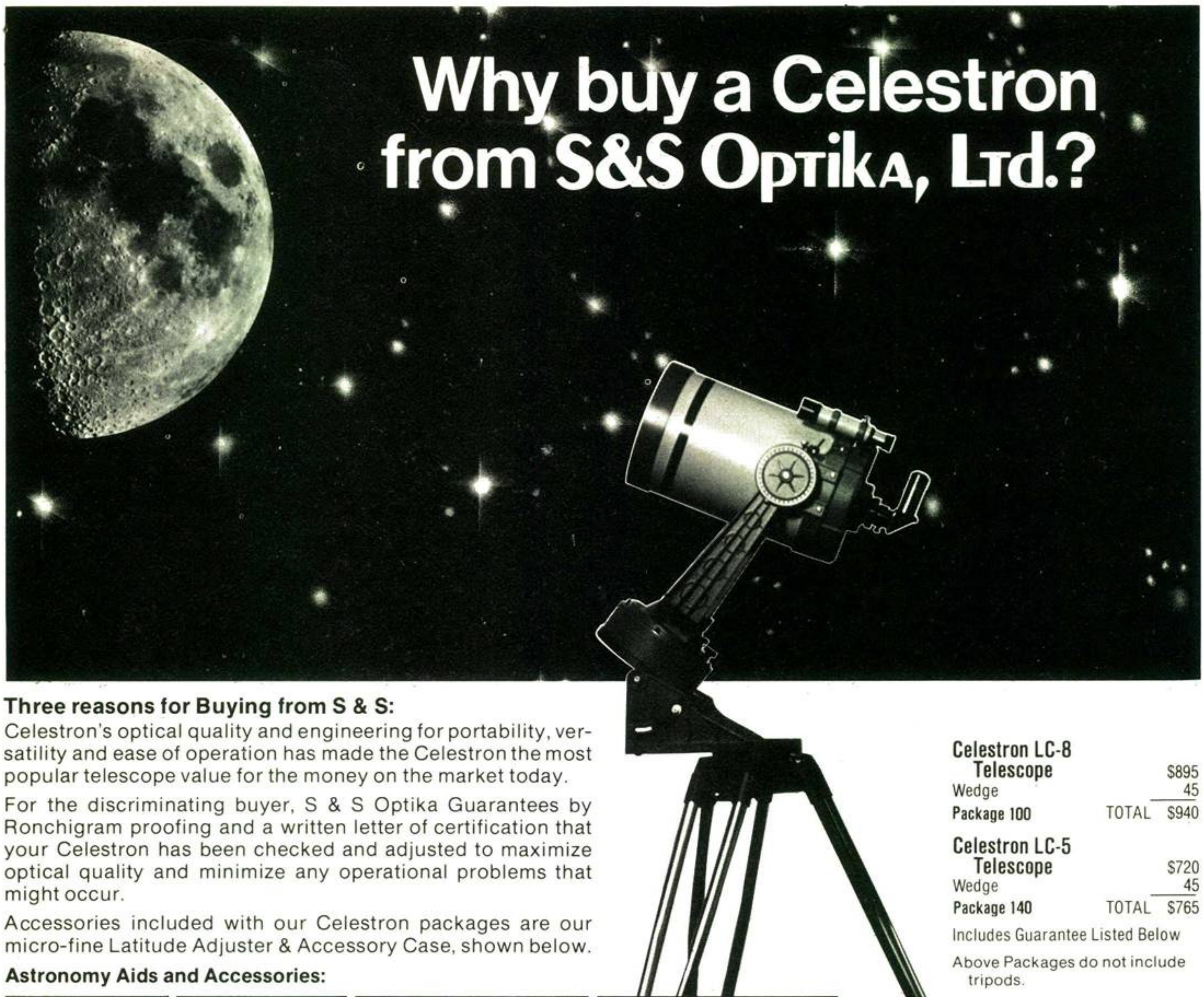
Thus, a new concept enters the scene. Strong stellar winds, streams of high-energy particles blowing outward from the surfaces of stars, may also clear out a wide region of space around stars. What, for instance, would cause the familiar hollow region of ringlike nebulae and prevent the nebular gas from back-expanding towards the central star? Stellar winds. The sharp inner edge of the Ring nebula's "donut" must be bombarded continually by such a wind, otherwise thermal expansion of the hot ionized nebula would quickly fill up the space around the star. A similar effect is at work in the Helix. This magnificent specimen shows fascinating structural details, including cometlike rays extending away from the remnant star behind globules of denser gas at the ring's inner edge. These delicate rays, visible to us only because of the Helix's relative proximity, are probably streams of ionized gas shorn from the globules by a continuous stream of high-energy particles.

And what of the central star? Let's not forget that it, too, is evolving and changing throughout the lifetime of its more spectacular lost atmosphere. Generally, once a star has shed its hydrogen-rich envelope, it slides down the long, slippery slope to become just another white dwarf in a galaxy of many such burned-out remnants. In most cases there is simply nothing to prevent this sedate, undisturbed cooling to oblivion from occurring. Think what might happen though if a part of the hydrogen envelope remained — a thin mantle of fusible star material resting on a dead carbon core. Now, the star lies dormant for a while after the release (explosive or gradual) of its first nebular shell. Then a few thousand years later it may repeat the process and surround itself with a superb double shell structure. NGC-2392, the Eskimo nebula, may have formed in this way.

Though the last act of massive stars in their supernova stage is more awesome and dramatic, stars of moderate mass like the sun still have their blaze of glory. Planetary nebulae are more, too, than just showpieces of late stellar evolution. They're a vital cog in the huge galactic machine, feeding matter back into the interstellar medium from which new stars will ultimately form.

David Darling received his doctorate from the University of Manchester (England). For his thesis topic he chose the dynamics of multi-envelope planetary nebulae. He is currently working on a comprehensive source book dealing with unusual and peripheral scientific phenomena.

Why buy a Celestron from S&S Optika, Ltd.?



Three reasons for Buying from S & S:

Celestron's optical quality and engineering for portability, versatility and ease of operation has made the Celestron the most popular telescope value for the money on the market today.

For the discriminating buyer, S & S Optika Guarantees by Ronchigram proofing and a written letter of certification that your Celestron has been checked and adjusted to maximize optical quality and minimize any operational problems that might occur.

Accessories included with our Celestron packages are our micro-fine Latitude Adjuster & Accessory Case, shown below.

Celestron LC-8 Telescope		$895
Wedge		45
Package 100	TOTAL	$940
Celestron LC-5 Telescope		$720
Wedge		45
Package 140	TOTAL	$765

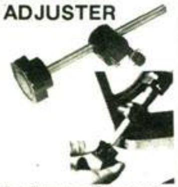
Includes Guarantee Listed Below

Above Packages do not include tripods.

Colorado residents include 3% Sales Tax.

Astronomy Aids and Accessories:

MICRO-FINE LATITUDE ADJUSTER



For Celestron Telescopes
- Full Latitude Control at Your Fingertips $19

WEATHERPROOF ACCESSORY CASE

- Carries Six Eyepieces, Diagonal, Tele-extender Telecompressor, Filters, etc. (Not included) $14

VARIABLE FREQUENCY DRIVE CORRECTOR

- 25-Watt Output
- Solar, Lunar and Sidereal Presets
- Infinitely Adjustable Base Rate
- Instantaneous Add and Subtract Pulse Buttons
- Fully Grounded for Safety
- Includes 20', 12-Volt Car Cable
- 12-Volt DC or 115-Volt AC Operation
- Coil Cord Included (Option Straight Cord) please specify length $114

MICRO-GUIDE

- Output-Frequency Continuously Variable from 50-70 Cycles
- 6 Watt Grounded Output Can Drive a Celestron 8
- NASA Spec Circuit Board
- 15' of Battery Cable $39

GUARANTEE

S & S Optika Guarantees to test & proof your Celestron, in its Optical Laboratory and perform the necessary adjustments to maximize its optical quality & minimize any mechanical operational problems that might occur. S & S Optika will furnish a letter of certification and a 200 Line Ronchigram proofing of the optical quality.

S&S Optika, Ltd.
3855 S. Broadway,
Englewood, CO 80110
Telephone (303) 789-1089

FREE! Send me FREE INFORMATION about S & S Optika Products. ☐
We are also Dealers for Edmund & Unitron.

Celestron
Telescopes... Telephoto Lenses... Binoculars

Here is my order for:
- ☐ Accessory Tray—$20.00
- ☐ Accessory Case
- ☐ Latitude Adjuster
- ☐ 25 wt. VFO
- ☐ 6 wt. Micro-Guide
- ☐ Star Atlas—$7.75
- ☐ Celestron-Package 100
- ☐ Celestron-Package 140

Include check, money order or Master Charge Acct. # with your order.

Send me the above Illustrated 32 page Celestron Color Catalog—$2.00. ☐

Name ______________________

Address ______________________

City ____________ State ________ Zip ________

Telephone & Area Code (   ) ____________ **Dept. A**

Meade precision 6" and 8" reflecting telescope systems give you full photo-visual capabilities.

Meade 6″ and 8″ reflectors achieve a new level of optical and mechanical excellence for the serious amateur. These totally integrated telescope systems include everything required for detailed study of the Solar System and Deep Space, and readily permit the observer to grow into more advanced subjects, such as long-exposure astrophotography. Designed by Meade engineers and manufactured at our Costa Mesa facility, these telescopes possess capabilities generally obtainable only at much higher prices—and they are the only telescopes available which use exclusively the quality Meade components known throughout the astronomical world.

Research-Grade Optics: Meade paraboloidal primary mirrors and elliptical secondary mirrors are of fine-annealed Pyrex, ground and polished to 1/10-wave surface accuracies. There are no finer optical systems obtainable.

Precision-Machined Equatorial Mounts: Each mount includes a ball bearing at the critical thrust point of the Polar Axis, and will easily accept the weight of heavy cameras, guide telescopes, and auxiliary systems. Mount components are individually machined at our factory to tolerances within .001″. Setting circles are provided on both axes for the location of faint objects.

Accurate Electric Drive Systems (115v/60Hz): Utilize clutch and gear components designed to satisfy rigid astrophotographic requirements. On models which include the Meade motor drive system, a manual override control in R.A. is available, for precise centering of objects in the telescopic field. For foreign operation, 220v/50Hz drives are available.

Full Photographic Capability: All instruments include prepositioned focal point settings for both eyepiece-projection and first (prime) focus astrophotography.

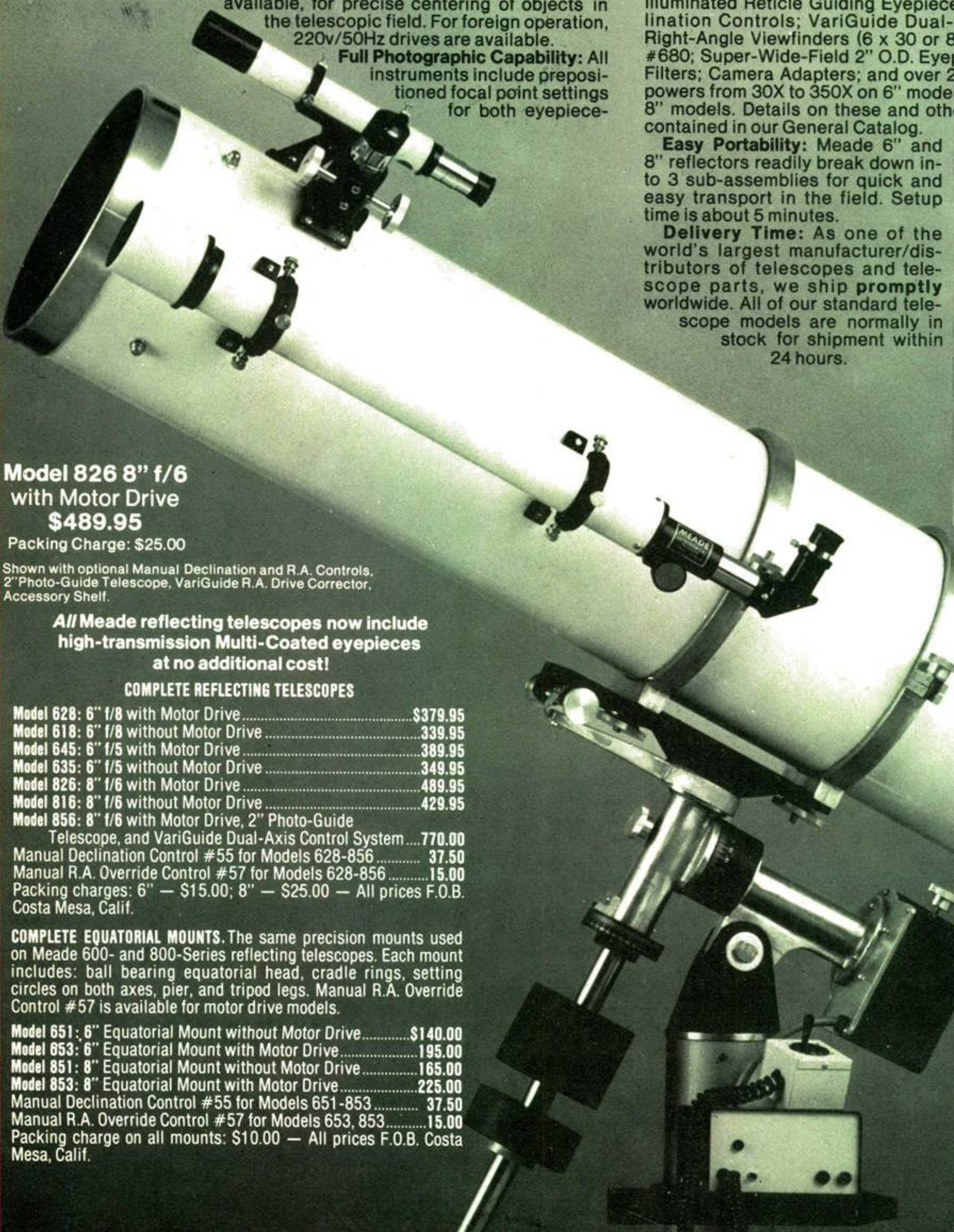
Quality Components and Accessories: Standard equipment on all 6" and 8" Meade reflectors — 6 x 30mm achromatic viewfinder with crosshair eyepiece; precision #67 rack and pinion focuser accepting 1¼" O.D. eyepieces; gleaming white Fiberlite tube, fully rotatable, with polished metal end rings; 4-vane spider; and 2 high-transmission, Multi-Coated Modified Achromatic eyepieces: 9mm (135X) and 25mm (49X).

Optional Systems and Accessories: Buy a telescope which will expand to fill your future requirements. Meade optional accessories permit the widest possible opportunity for advanced applications, and each accessory, as part of an integrated system, attaches easily and accurately to any Meade reflector. Optional accessories which may be ordered either with the telescope or at a later date include: 2" Photo-Guide Telescope; Illuminated Reticle Guiding Eyepiece; Manual or Electric Declination Controls; VariGuide Dual-Axis Corrector Systems; Right-Angle Viewfinders (6 x 30 or 8 x 50); Deluxe 2" Focuser #680; Super-Wide-Field 2" O.D. Eyepieces; Photo-Visual Color Filters; Camera Adapters; and over 20 additional eyepieces for powers from 30X to 350X on 6" models and from 30X to 550X on 8" models. Details on these and other Meade accessories are contained in our General Catalog.

Easy Portability: Meade 6" and 8" reflectors readily break down into 3 sub-assemblies for quick and easy transport in the field. Setup time is about 5 minutes.

Delivery Time: As one of the world's largest manufacturer/distributors of telescopes and telescope parts, we ship **promptly** worldwide. All of our standard telescope models are normally in stock for shipment within 24 hours.

Model 628 6" f/8
with Motor Drive
$379.95
Packing Charge: $15.00
Shown with optional camera adapter



Model 826 8" f/6
with Motor Drive
$489.95
Packing Charge: $25.00

Shown with optional Manual Declination and R.A. Controls, 2" Photo-Guide Telescope, VariGuide R.A. Drive Corrector, Accessory Shelf.

***All* Meade reflecting telescopes now include high-transmission Multi-Coated eyepieces at no additional cost!**

COMPLETE REFLECTING TELESCOPES

Model 628: 6" f/8 with Motor Drive	$379.95
Model 618: 6" f/8 without Motor Drive	339.95
Model 645: 6" f/5 with Motor Drive	389.95
Model 635: 6" f/5 without Motor Drive	349.95
Model 826: 8" f/6 with Motor Drive	489.95
Model 816: 8" f/6 without Motor Drive	429.95
Model 856: 8" f/6 with Motor Drive, 2" Photo-Guide Telescope, and VariGuide Dual-Axis Control System	770.00
Manual Declination Control #55 for Models 628-856	37.50
Manual R.A. Override Control #57 for Models 628-856	15.00

Packing charges: 6" — $15.00; 8" — $25.00 — All prices F.O.B. Costa Mesa, Calif.

COMPLETE EQUATORIAL MOUNTS. The same precision mounts used on Meade 600- and 800-Series reflecting telescopes. Each mount includes: ball bearing equatorial head, cradle rings, setting circles on both axes, pier, and tripod legs. Manual R.A. Override Control #57 is available for motor drive models.

Model 651: 6" Equatorial Mount without Motor Drive	$140.00
Model 653: 6" Equatorial Mount with Motor Drive	195.00
Model 851: 8" Equatorial Mount without Motor Drive	165.00
Model 853: 8" Equatorial Mount with Motor Drive	225.00
Manual Declination Control #55 for Models 651-853	37.50
Manual R.A. Override Control #57 for Models 653, 853	15.00

Packing charge on all mounts: $10.00 — All prices F.O.B. Costa Mesa, Calif.

Meade

Research level telescope parts and accessories from America's No. 1 supplier to the serious amateur

RACK-AND-PINION FOCUSERS — Precision metal construction. All 3 models include helical-cut rack and variable-tension adjustment for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1¼" eyepiece holders. **Each focuser is guaranteed to be the finest obtainable in its class.**

1 — **MODEL 67** — Strong, lightweight design for 4" to 10" telescopes. 2-3/16" travel. An excellent value. **$19.75 ppd.**

2 — **MODEL 640** — A heavy-duty deluxe focuser for 6" to 16" telescopes. Full 3" travel for both visual and photographic applications. **$32.95 ppd.**

3 — **MODEL 680** — Our finest focuser. Accepts both 1¼" and 2" eyepieces. Full 3" travel for photo or visual observing with 6" to 16" telescopes. **$38.75 ppd.**

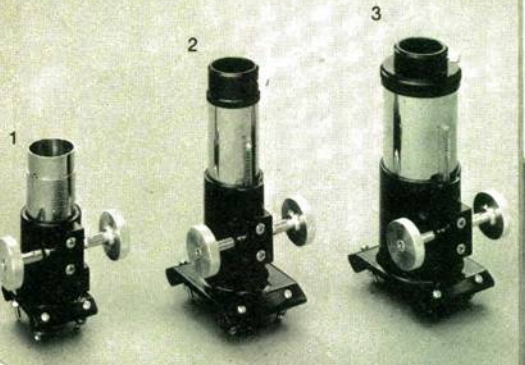
4 — **NEBULAR FILTER** — This revolutionary 3-channel filter effectively blocks sodium and mercury emissions from city lights as well as natural airglow, while transmitting 90% of critical visual nebular emissions. Dramatically improves telescope performance visually and photographically. Hermetically sealed, anti-reflection coated. 23mm clear aperture. Threads directly into all Meade 1¼" O.D. eyepieces. **$49.95 ppd.**

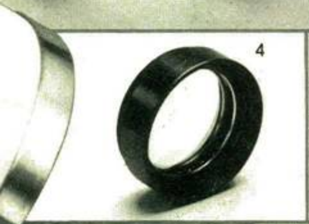
5 — **PHOTO-VISUAL COLOR FILTERS** — Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Mounted in machined metal cells which thread directly into all our 1¼" "Series 1", "Series 2", and "Research-Grade" eyepieces. Filters may be piggybacked. Listed by Wratten No. and color: **#8 Light Yellow — #11 Yellow-Green — #12 Yellow — #21 Orange — #23A Light Red — #25A Red — #47 Violet — #58 Green — #80A Blue — Polarizer (30% transmission).** Each filter: **$6.95 ppd.** Set of any 6: **$39.50 ppd.** — Full set of 10: **$64.50 ppd.**

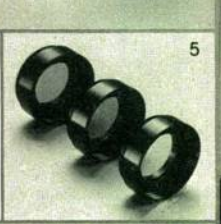
6 — **VARIPAK DRIVE CORRECTOR** — This low-cost quality unit includes all the features required for the majority of guiding applications. New super-compact (2" x 3" x 4") design, with fast-slow pushbuttons mounted on the power pack. Variable control for lunar, planetary, sidereal rates. Operates from 12 volts D.C. The 8-watt output is sufficient for most telescopes to 10" aperture. **$59.95 ppd.**

7 — **VARIGUIDE DRIVE CORRECTORS** — The finest R.A. drive correctors available. Each unit includes aircraft-type joystick controller for continuously variable correction rates, not just "ON-OFF". Models 40 and 41 may be used with any motor-drive-equipped telescope rated up to 10 watts, including most commercial telescopes to 12½" aperture.
Model 40 — Operates from 12 volts D.C. Control box includes variable center-frequency settings for lunar, planetary, sidereal rates. **$89.95 ppd.**
Model 41 — Identical to Model 40, but operates from either 12 volts D.C. or 115 volts A.C./60Hz. **$119.95 ppd.**

8 — **VARIGUIDE DUAL-AXIS CORRECTOR SYSTEMS** — For the advanced astrophotographer. Universal joystick controllers permit continuously variable correction rates **simultaneously** on **both** telescope axes. Each unit includes electronic control systems for both R.A. and Declination, along with all required mounting hardware. Models are available to fit Meade 600- and 800-Series reflectors and for the Celestron 5 and 8, as noted. After 15 minutes' installation, you will be using the most sophisticated and precise guiding system ever offered the serious amateur.
Model 47M — Attaches to Meade 600- and 800-Series reflectors. Operates from either 12 volts D.C. or 115 volts A.C./60Hz. **$215.00 ppd.**
Model 47C — Attaches directly to Celestron 5" and 8" telescopes. Operates from either 12 volts D.C. or 115 volts A.C./60Hz. **$195.00 ppd.**







New! Multi-Coated Series 2 and Research-Grade Eyepieces

Manufactured to entirely new Meade designs, these Series 2 eyepieces are a significant advance in eyepiece technology. Utilizing modern high-density optical glasses, each eyepiece has been computer optimized to yield the highest level of optical performance obtainable within its design class. Air-to-glass surfaces on all Series 2 and Research-Grade eyepieces are Multi-Coated for maximum light transmission and image contrast. All 1¼" barrels are threaded for Meade filters.

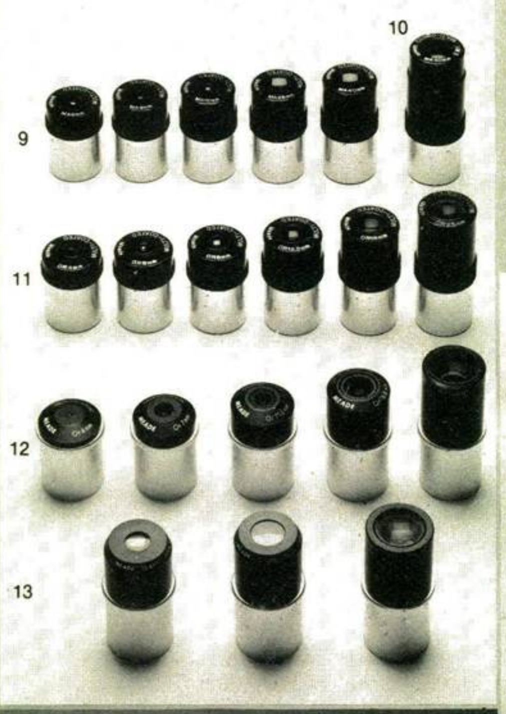
9 — **SERIES 2 MODIFIED ACHROMATIC EYEPIECES (1¼" O.D.: MULTI-COATED)** — Fine 3-element systems, precisely corrected for chromatic and spherical aberrations. Guaranteed to be the finest eyepieces obtainable for under $25.00. **FOCAL LENGTHS: MA 6, 9, 12, 25mm and 40mm Wide-Field . . . each $19.50 ppd.**

10 — **MODIFIED ACHROMATIC 40mm EXTRA-WIDE-FIELD EYEPIECE (1¼" O.D.: MULTI-COATED)** — Yields widest field obtainable in 1¼" O.D. Enlarged field lens and special field-flattening optics with long eye relief. **$24.75 ppd.**

11 — **SERIES 2 ORTHOSCOPIC EYEPIECES (1¼" or .965" O.D.: MULTI-COATED: PARFOCAL)** — The excellent 4-element high resolution optics of these oculars are all that the majority of serious amateurs will ever require. Razor sharp 45° fields. Both the 1¼" and .965" O.D. sets are accurately parfocalized. **FOCAL LENGTHS: OR 4, 6, 9, 12.5, 18, and 25mm . . . each $27.95 ppd.**

12 — **RESEARCH-GRADE ORTHOSCOPIC EYEPIECES (1¼" O.D.: MULTI-COATED: PARFOCAL)** — The largest selling premium-quality eyepieces in the world, universally acclaimed to be the finest eyepieces obtainable. These 4-element systems are unsurpassed in color correction, resolution, and flatness of field. 45° field. Accurately parfocalized. **FOCAL LENGTHS: OR 4, 7, 10.5, 16.8, 28mm . . . each $38.95 ppd.**

13 — **RESEARCH-GRADE ERFLE EYEPIECES (1¼" O.D.: MULTI-COATED: PARFOCAL)** — For breathtaking wide-angle observations. 65° to 75° fields, parfocalized with our Research-Grade Orthoscopics. **FOCAL LENGTHS: ER 12.4, 15.5, 20mm . . . each $44.50 ppd.**



VIEWFINDERS — Each includes coated, achromatic objective lens and crosshair eyepiece:

14 — **6 x 30mm** — Fine 4° wide-field finder. Thousands now in use. 2-ring bracket included, fits all tubes 6" to 12½". **$21.95 ppd.**

15 — **6 x 30mm RIGHT-ANGLE** — As in (14) but with diagonal prism for convenient right-angle observations. Bracket included. **$27.95 ppd.**

16 — **8 x 50mm** — 5° field and large 50mm aperture. Sharp, brilliant images. **$33.95 ppd.** Brackets: **$7.95/pr. ppd.**

17 — **8 x 50mm RIGHT-ANGLE** — As in (16) but with diagonal prism, for right-angle viewing. **$39.95 ppd.** Brackets: **$7.95/pr. ppd.**

18 — **ERFLE 32mm EYEPIECE (2" O.D.)** — Sophisticated 5-element optical system. Wide, flat 65° field. The ultimate in rich field performance, for 2" focusers. **$94.50 ppd.**

19 — **KELLNER 60mm EYEPIECE (2" O.D.)** — Low power, long eye relief. Ideal for deep-space observations. Fully coated. **$49.50 ppd.**

20 — **DELUXE CAMERA ADAPTERS** — Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum and brass. All units permit both eyepiece-projection and first (prime) focus photography. Specify either 1¼" or .965" focuser. All 1¼" units are threaded for our filters. **Pentax, Yashica, Mamiya . . . $18.95 ppd. — Nikon, Canon, Minolta, Pentax K, Exakta, Konica, Olympus OM-1, OM-2 . . . $26.75 ppd.**

21 — **2X TELENEGATIVE AMPLIFIER (1¼" O.D.: MULTI-COATED) — Model 122:** Warranted without qualification to be the world's finest Barlow lens. Full 26mm clear aperture, Multi-Coated, with virtually flawless optical corrections at all photo-visual wavelengths. Produces optimum performance on telescopes of any focal ratio . . . **$29.50 ppd.** **Model 131:** Per Model 122, but for .965" focusers; 18mm clear aperture, Multi-Coated . . . **$24.50 ppd.**

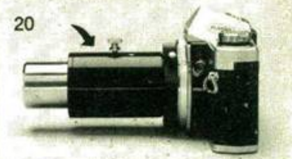
22 — **2X-3X VARIABLE TELENEGATIVE AMPLIFIER (1¼" O.D.: MULTI-COATED) — Model 127:** Manufactured to the same research standards as the Model 122 above, but mounted in a precisely machined sliding cell, to permit variable power settings between 2X and 3X. Engraved scale indicates power. Multi-Coated . . . **$36.50 ppd.**

23, 24 — **ACCESSORY CASES** — Rugged polyethylene, for dust-free protection of eyepieces, filters, Barlows, etc. Die-cut foam lining. **Model 51: 7" x 8½" . . . $8.95 ppd. — Model 54: 8" x 12" . . . $12.95 ppd.**

25 — **ILLUMINATED RETICLE GUIDING EYEPIECE (1¼" or .965" O.D.)** — New phosphorescent etched double-line reticle permits line illumination from dim to extremely bright. Remote brightness control and 6 ft. cable. Modified Achromatic 12mm optical system. Precisely focusable reticle. Complete . . . **$47.50 ppd.**
Micrometer Reticle: Full-field scale for accurate measurements of double star separations, planetary angular diameters, etc. Interchanges with standard 4-line reticle . . . **$14.95 ppd.**

26 — **ERECTING PRISMS** — Fully coated Porro prisms, for terrestrial observations with astronomical telescopes. **1¼" O.D. . . . $32.95 ppd. — .965" O.D. . . . $19.95 ppd.**

27 — **DIAGONAL PRISMS** — Quality right angle prisms, fully coated. **1¼" O.D. . . . $19.95 ppd. — .965" O.D. . . . $14.95 ppd.**



Mail Orders: Write us your requirements — or use the order form which accompanies our catalog.
Telephone Orders: Accepted with payment either C.O.D. or credit card (we do not accept collect calls).
Payment: Personal or bank check, money order, or credit card (BankAmericard/VISA or Master Charge).
Shipment: All orders are processed for shipment within 24 hours.
California Residents: Add 6% Sales Tax. **Canadian Orders:** Add 10% to cover priority mail charges.
Foreign Orders (Outside North America): Add 20% to cover Air Parcel Post charges. Payment must be made by bank check in US $.
General Catalog 79-C — $1.00 (Outside North America $2.00 for Air Mail). (Catalog free with any order.)

Card No.____________________Expiration Date / /
Name____________________
Address____________________
City____________State________Zip________

Meade Instruments Corporation 721 W. 16th Street, Costa Mesa, Calif. 92627 **(714) 646-9281**

© 1979 Meade Instruments Corp. TM Series 2, Research-Grade, Fiberlite, VariGuide, and VariPak are trademarks of Meade Instruments Corp.

Patrolling the Planets

by
Robert Burnham
and
Dewey Schwartzenburg

How familiar are you with our own astronomical neighborhood? How well do you know the planets? Or are you one of the many who feel NASA has somehow pre-empted all the interesting discoveries in the solar system? If you're one of those people, you're missing something, both in terms of personal interest *and* from a scientific point of view!

No one is trying to kid you into believing that great new breakthroughs await you and your telescope as you patrol the planets from your backyard (and for this you can thank NASA for the terrific job they're doing); however, if you start a regular program of observing the planets, you'll soon find that you've learned far more about them than you ever thought possible. Moreover, you have an added spur to your efforts since you just might see something in your patrols that has escaped the professionals' notice. After all, they haven't time or personnel enough to spend every clear night carefully observing all the visible planets.

In the course of watching Jupiter, say, for six months, you'll pick up a tremendous amount of experience. It's a truism among observers that when you start watching a planet, you'll need far more aperture and magnification to see something than you will weeks later. Your equipment doesn't change over the time, but your perceptive ability will increase dramatically. The importance of regular observing can't be stressed enough.

About a decade ago, NASA established an International Planetary Patrol among several professional observatories. Recently, lack of funds forced severe reductions of the program. While you won't be able to match in size or equipment the sophistication of a professional observatory, private observers like yourself now have a golden opportunity for doing patrol work on the planets.

But, you protest, I have only that crummy little 2.4 inch refractor (or four inch reflector, or whatever); what can I *do* with it? Don't knock it, for a start! Your small telescope is by no means as negligible as you may think. If you'd like to learn a systematic approach to planetary observing that you'll find both fun and scientifically rewarding, read on!

Mercury

If we start with the innermost planet of the solar system, at once we seem to contradict our earlier statements about the value of small telescope observations. The truth is, for love or money, your Earth-bound telescope (no matter how good) just isn't going to show you much of Mercury. The planet never gets far above the horizon and spends all its time close to the glare of the sun.

Nothing much was learned about the planet's physical nature until the mid-1960s when radar studies revealed the true rotation period, and gave hints that the surface composition was basically lunar. But it took a spacecraft (Mariner 10) to show what half the planet really looked like.

At the outset then, you have little hope of seeing much. In reality, about all you can do is follow the changing phases, and hope to glimpse a few of the dusky markings of the surface. These markings take luck and skill to see, but by repeated observation, you can maximize your luck and acquire the skills.

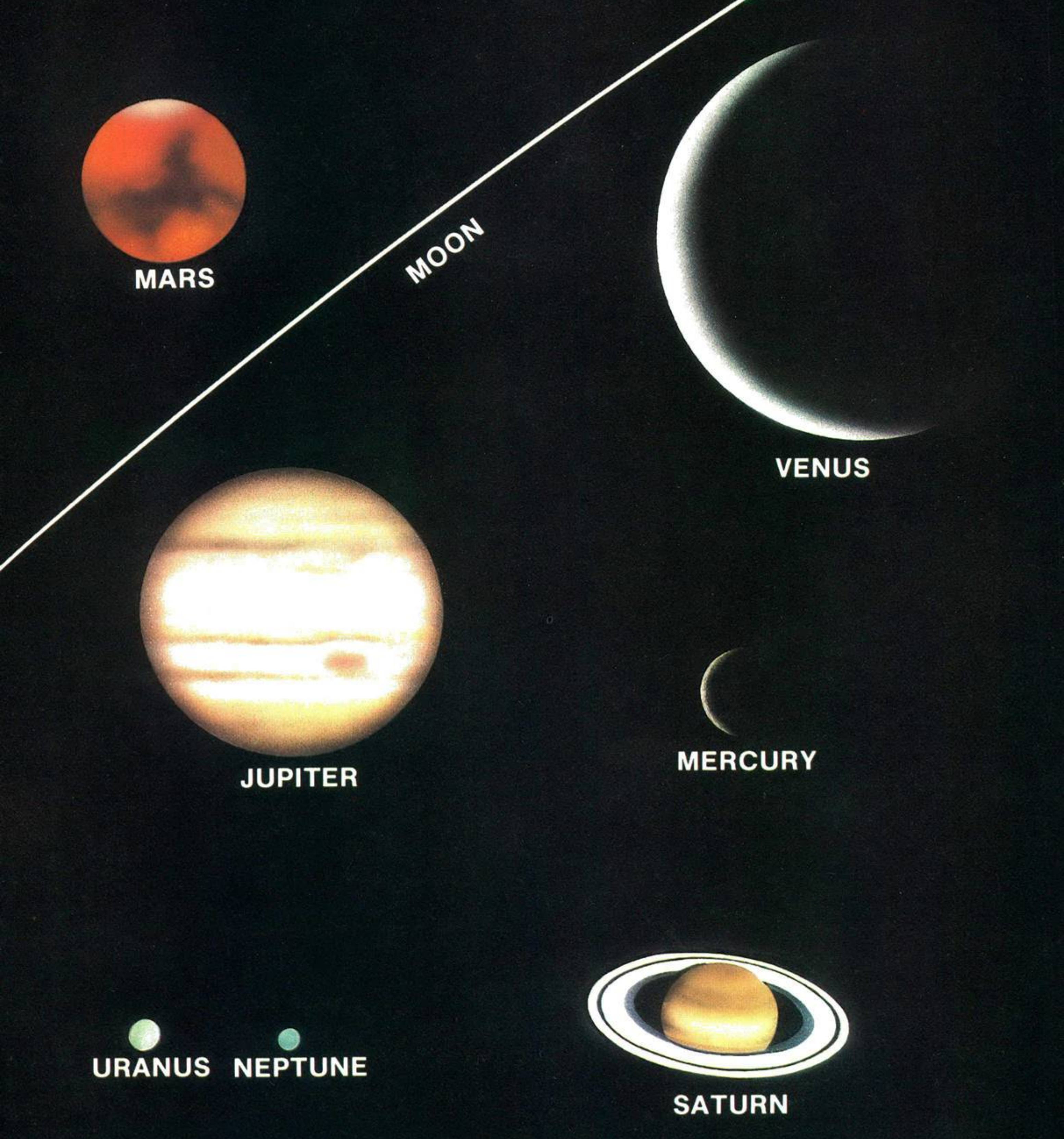
Many people have found the time of day for observations very critical. You should be looking at a time when the contrasts are strongest; remember, you're hunting for *faint* differences. This means you want to pick a time when your eye is neither dazzled by a bright planet in a dark sky, nor straining after details on a disk washed out by skylight.

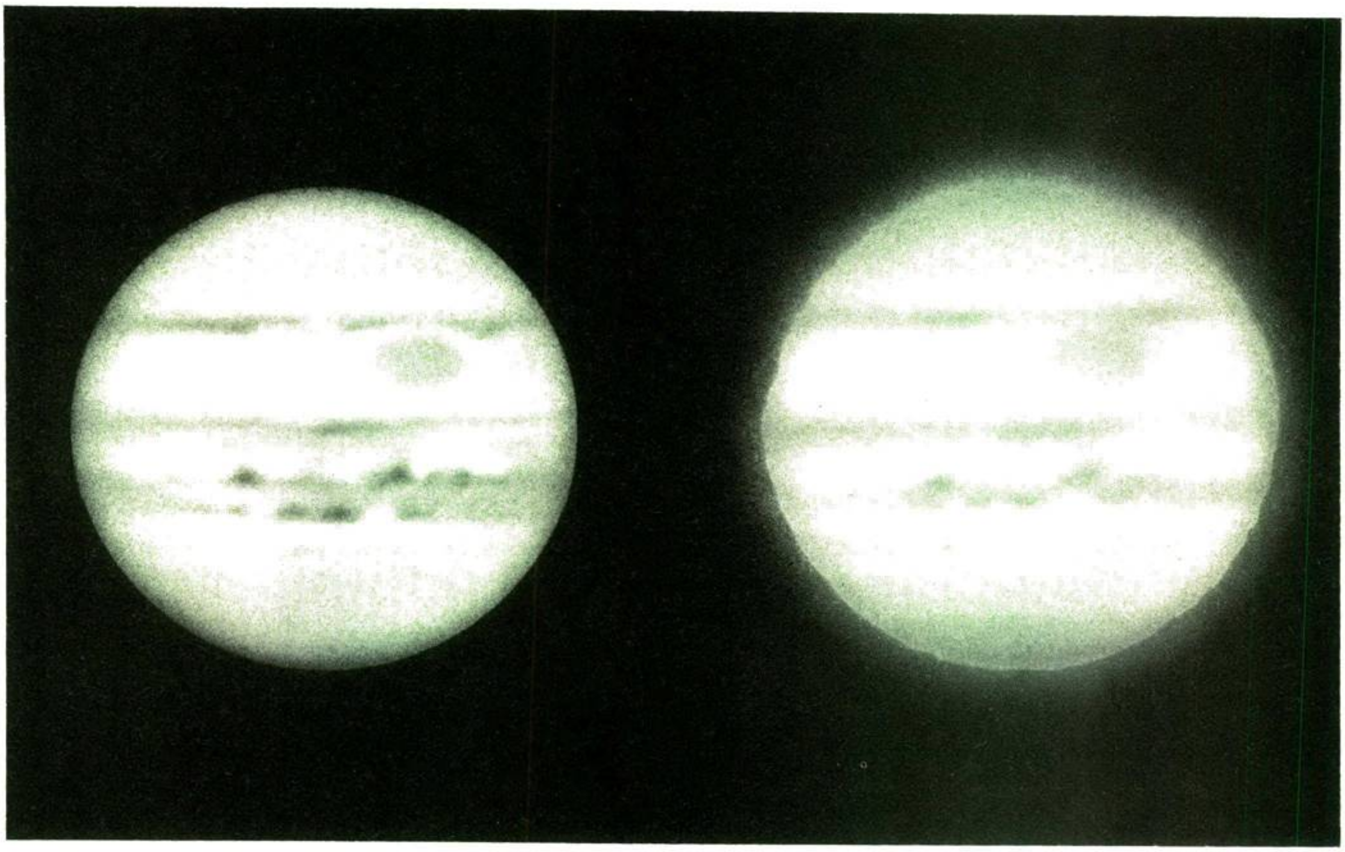
You'll find that using filters makes the job easier. When you set up a regular observing program, you ought to have a number of filters for use at the eyepiece. You can spend a great deal of money on precision-made glass filters, but the ordinary gelatin ones available in photo stores will work fine, if you take care of them. (And when they get too scratched to use, their replacement cost is reasonable.) You'll need an assortment of color filters to start with (red, green, blue and yellow), and get a couple of neutral density (colorless) ones as well.

With Mercury, most observers feel that a blue filter has the best chance of showing details on the surface. A neutral density filter will help you if the twilight is bright.

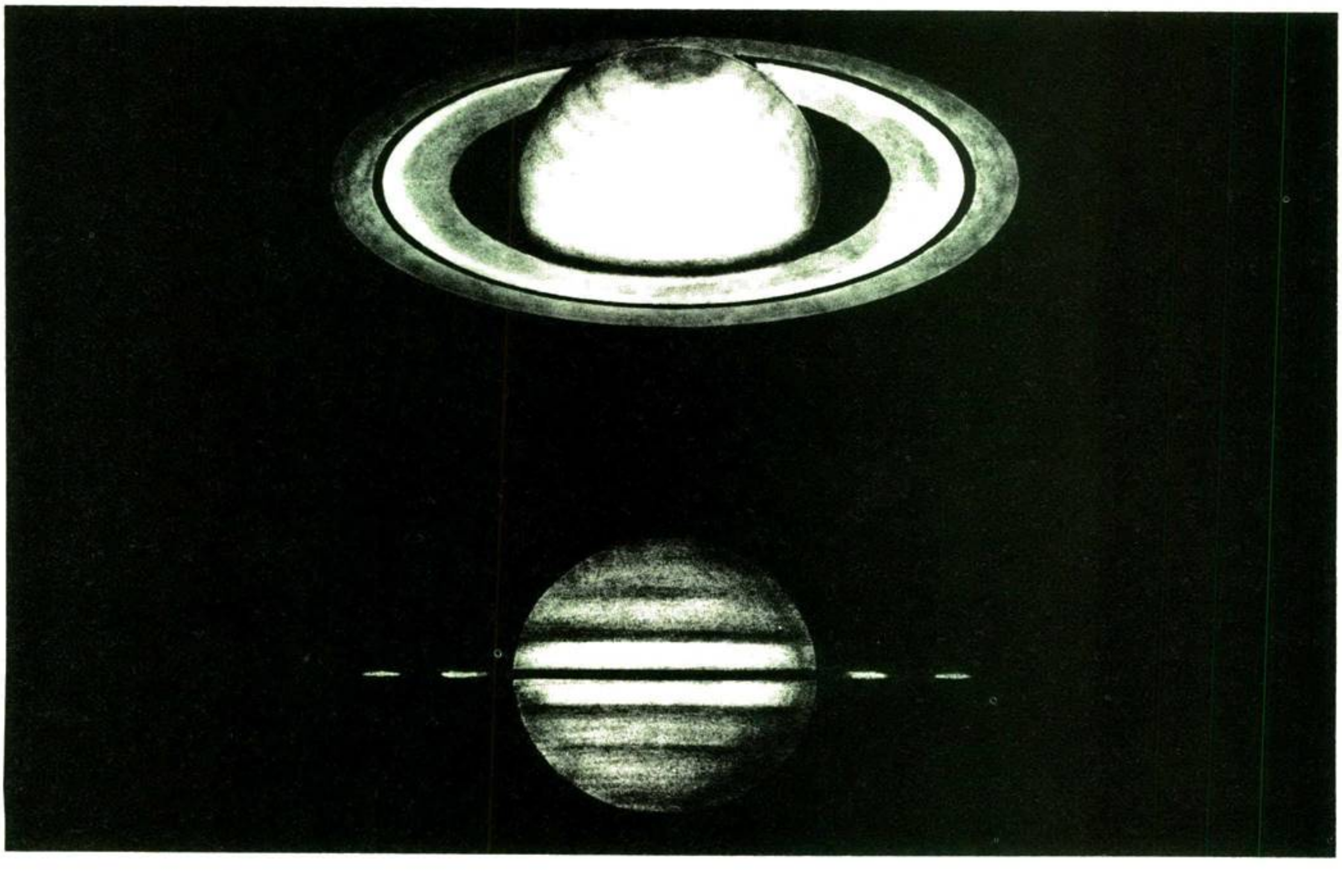
You should get in the habit of recording your observations, even the negative ones where you see nothing but a featureless disk. Who knows, perhaps the fact that you saw nothing

The planets' relative apparent sizes when at or near their closest approach to Earth are shown below, along with an arc representing the limb of the moon drawn to the same scale. The full moon would be a disk over six feet in diameter! Mars is shown at a perihelic opposition, which occurs only every 16 years or so. It can be up to as much as 40 percent smaller in apparent diameter at other oppositions! When Mercury and Venus are at their closest, they show only thin crescents, for they lie between us and the sun. The apparent orientation of Saturn's rings varies as it moves around in its 29 year orbit. Pluto, visible only as an exceedingly dim star, is not shown. Artwork by Victor Costanzo.





Above: These two drawings of Jupiter show the importance of "seeing" for planetary observations. The image at right is considerably blurred with a great loss of detail. At left, Jupiter is shown as it would appear at high powers in a moderate size (8 to 16 inch) telescope under conditions of excellent seeing. At times, momentary clearing may enable even greater definition of detail. Drawing by Victor Costanzo. Below: These classic drawings show Saturn's rings at two extreme orientations: fully open and edge-on. Scattered light can make the exceedingly thin rings faintly visible even when edge-on, as many observers have reported. Drawings by Edward Emerson Barnard.



may turn out to be important! (Sherlock Holmes fans will recall the dog that *didn't* bark in the night.)

One convenient way to record your results is with a simple sketch. Don't complain that you can't draw worth beans — it doesn't matter. A sketch is more like visual note-taking than an attempt to make a precise rendition of the appearance. Use a soft pencil (HB or F grade is best), and prepare ahead of time a circular blank about an inch in diameter — no larger. At the telescope, draw in the apparent terminator, and whatever else you see. Make notes *on* the sketch about the powers used and seeing conditions. Date it, and indicate the direction of north on the sketch. When you've finished it, leave it alone. If you have second thoughts later about a feature, record them in different pencil or ink, but try to make your original sketch as complete as possible.

Venus

Venus approaches closer to Earth than any other planet, but its ever-present cloud layer prevents any sight of the surface. Radar studies show that it's much like the surfaces of most terrestrial planets, rocky and cratered, but the only way we'll ever see it is by means of robot probe pictures.

On the other hand, the past history of Venusian observations is full of accounts of people seeing faint markings in the planet's clouds. The cameras aboard Mariner 10 showed that the markings, very prominent in the ultraviolet region of the spectrum, were produced by the Venusian atmosphere's four day rotation period. Since Venus' apparitions aren't as hurried as Mercury's, you might want to try looking for the markings over many consecutive days to see if 1) you can see them, and 2) you can detect any motions.

The following are some of the features, more or less elusive, to look for: irregularities in the terminator, patchy markings on the clouds, visibility (or not) of the unlit part and irregularities at the polar cusps. Most or all of these will be very subtle and hard to detect, so don't expect immediate results. Use a blue filter most of the time, but try the others as well.

You may also catch sight of a curious phenomenon, almost certainly an optical illusion, called the *ashen light*. It's a lightening of the unlit part of the disk relative to the sky surrounding the planet. (Some observers have reported seeing the ashen light on airless Mercury!) It shouldn't be confused with the ringlike appearance of the planet near times of inferior conjunction, when the sunlight, refracted and diffused through the planet's atmosphere, makes Venus look like a circle of light having a dark center. (For more on observing Mercury and Venus, see the December 1978 Gazer's Gazette.)

Mars

Most people's first impression of Mars through a telescope is one of disappointment. Where are all those canals? They may see darker patches here and there, and perhaps a polar cap gleams a bit, but overall, Mars doesn't seem to live up to its billing as a planetary attraction.

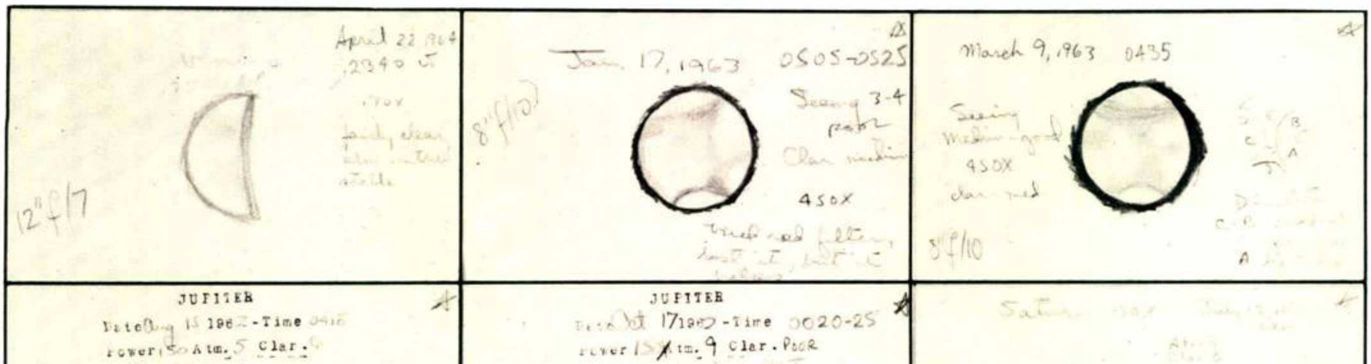
The problem, of course, lies in the diminutive size of Mars and the immense distances separating us from the planet. About the only time it is worthwhile to observe Mars is the few months just before and after opposition, when Mars comes closest to Earth. This occurs relatively rarely, at intervals of about two years. Otherwise, it's just too far away and too tiny in apparent size. Even the opposition distance varies greatly due to the large eccentricity of Mars' orbit, and therefore the apparent size at a particular opposition can be as small as 14 seconds of arc or as large as 25 seconds. *Mars at its best never appears larger than a small lunar crater.*

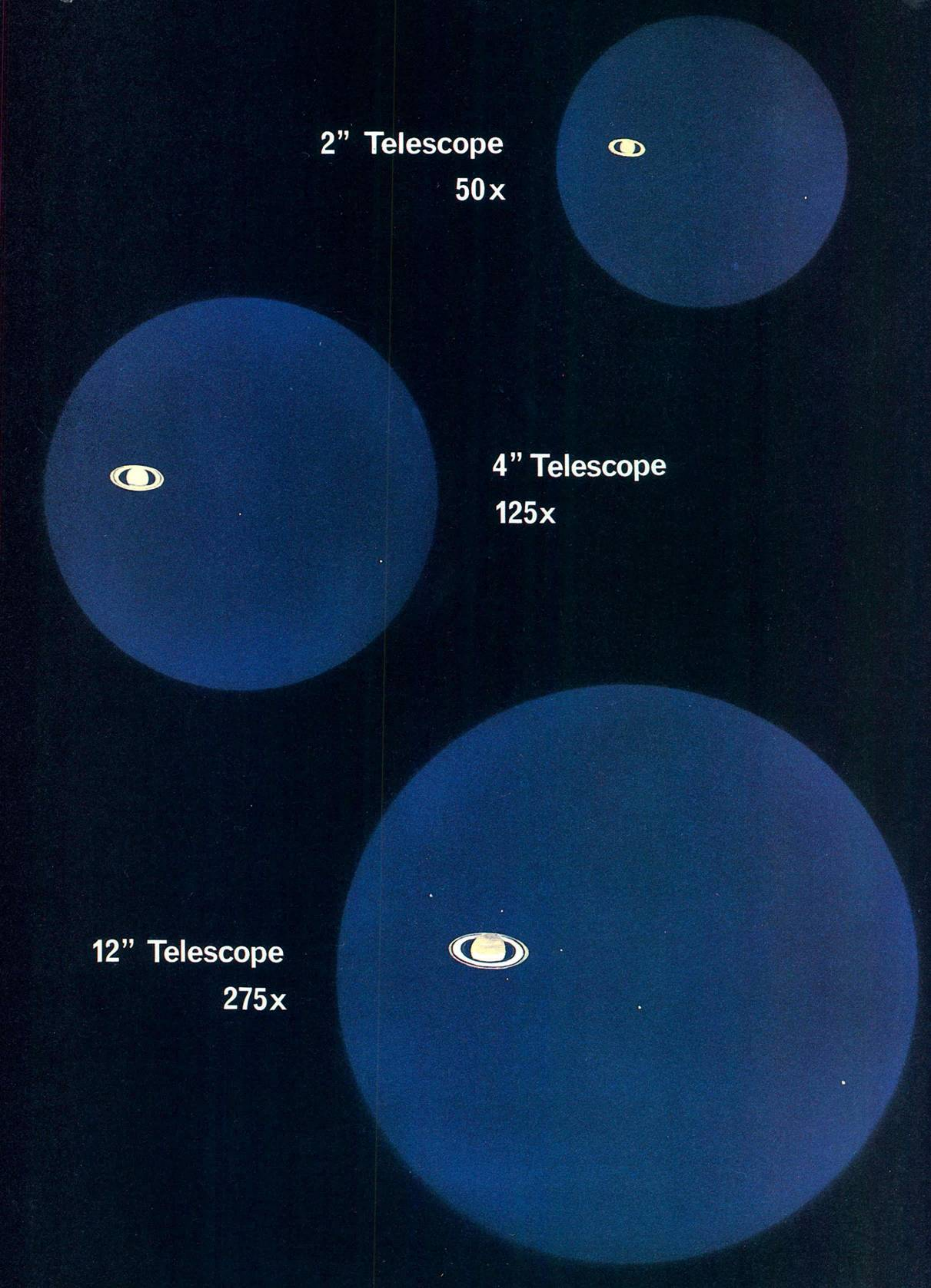
You should start observing Mars several months before an opposition. At first your observations will seem hopelessly bad, but if you persist, over the weeks you'll discover that you are seeing more and more. In part this happens because as opposition nears, the distance between Mars and us is decreasing and its apparent size, therefore, increases. But more importantly, you have been training your eye to perceive surface detail better and better. (You should start watching Mars several months before opposition, even though you may have to observe after midnight!)

One of the long-standing advantages to visual observation is that it can make the most of opportunities afforded by occasional moments of excellent seeing to grab at details usually lost in the blur. Planetary photography can't do this, since the long exposure times average out the good seeing with the bad, giving a degraded image overall.

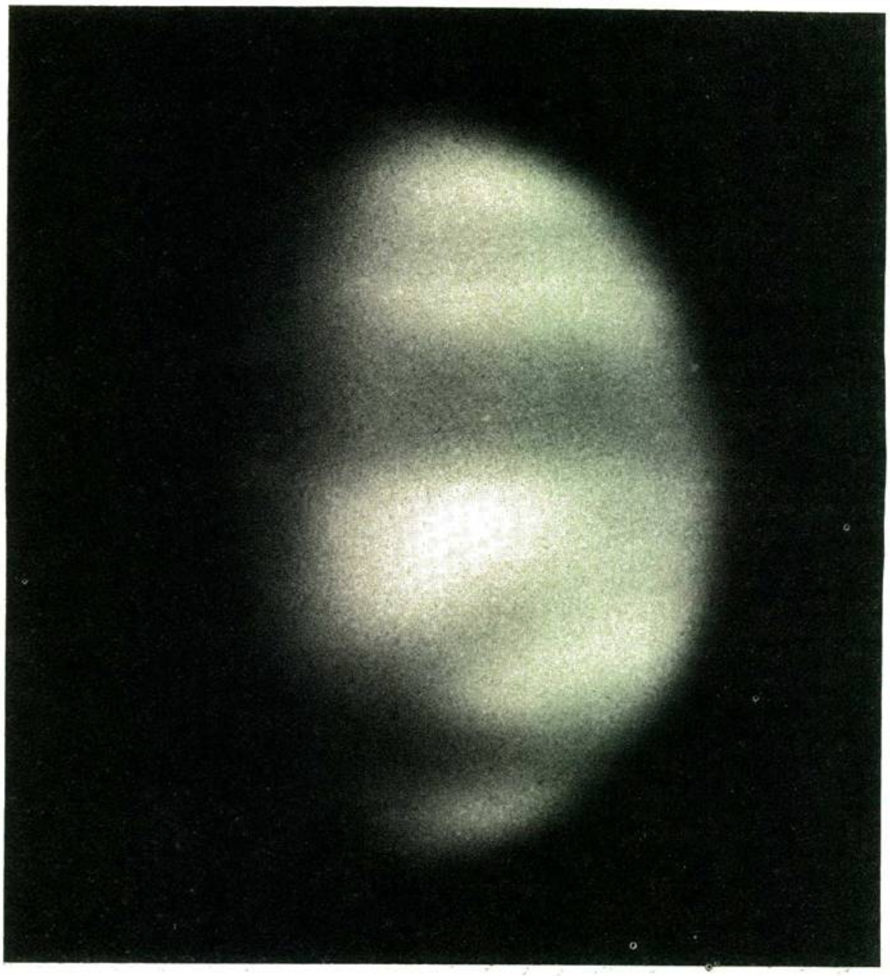
(But what's the point of it all? Haven't Mariner 9 and the Vikings given incredibly detailed photos — far beyond anything possible with Earth-based instruments? While this is true, don't forget that for these spacecraft, the picture part of the mission is over. If anyone wants to know what's

The pencil drawings below of Venus, Mars, Jupiter and Saturn, made during eyepiece observations, illustrate correct technique. Both the date and time are recorded, as well as the instrument used (e.g., 8 inch f/10), the magnification and brief notes on the observation itself. Such drawings made from direct visual observation can be especially valuable in recording features revealed briefly in moments of unusual transparency and image steadiness. For this reason, drawings often show more detail than photographs, which must average out the image quality over the period of exposure. Drawings by Richard Berry.




2" Telescope
50x
4" Telescope
125x
12" Telescope
275x

happening on Mars *now*, they have to go get a telescope and *look*.)



Venus, perpetually veiled by its cloud cover, rarely reveals any markings whatsoever. Sometimes, though, transient darker areas in the clouds are seen, such as in this photograph. These faint markings are most easily discerned with a blue filter. Photograph by LPL Catalina Observatory.

Periodically, Mars' atmosphere kicks up a dilly of a storm — in late 1971 when Mariner 9 arrived at the planet, the spacecraft might have been photographing a ping-pong ball for all the detail that came back. In addition, Mars now and then exhibits the phenomenon of *blue clearing*, when its atmosphere suddenly becomes very transparent, even through a blue filter (which normally prevents you from seeing the surface). Sometimes the clearing precedes a great dust storm like that of 1971, giving you a chance to do some long-distance Martian weather predicting! (In normal observation of surface markings, use an orange or red filter as it eliminates much of the Martian atmosphere's obscuring effects.)

One thing to remember when you observe Mars is that its rotation period is only 41 minutes longer than Earth's. This means that if you observe Mars on successive nights at about the same time, you'll be looking at the same features. In order to see the other side of the planet, you would have to wait more than 12 hours. So be prepared to get up occasionally at 4 a.m. in addition to evening observations if you want to see much of the planet's surface around the time of opposition.

You should try a sketch, so prepare blanks as you did for Mercury or Venus. Again, make them only about an inch in size, for if you make them much bigger, you'll be tempted to fill in details where you really can't see any. Start with the most prominent markings — usually the polar cap(s) — then work on finer details as you accustom your eye to the planet's appearance.

Jupiter

Without any question, Jupiter is the easiest planet to observe. It's big and bright, with readily discernable markings that change often. In fact, Jupiter has the largest apparent size of any planet except for Venus, but unlike Venus, which at its largest shows only a thin crescent, Jupiter always shows a full disk because it is farther from the sun than Earth. Furthermore, unlike both our closest neighbors Venus and Mars, distant Jupiter doesn't vary much in apparent size over the course of a year. About the only time Jupiter isn't worth observing is when it's in conjunction with the sun and hidden in its glare. Therefore more observers watch Jupiter than any other planet — and some watch only Jupiter.

The appearance of Saturn and its moons as seen through a variety of telescopes is shown on the opposite page. With a two inch telescope at 50x the rings can be made out and the brightest satellite, Titan, is visible. A four inch telescope at 125x can show the Cassini division and reveals one more satellite, Rhea. In a 12 inch telescope, surface detail can be distinguished while all three rings, including the faint innermost Crepe ring, stand out clearly. Six of Saturn's satellites are easily visible in the field of view. Artwork by Victor Costanzo.

Examining Jupiter is like observing Venus in one way: You're not seeing a planetary surface, but rather the top of an atmosphere. Very noticeable in Jupiter's case are the cloud belts clearly paralleling the Jovian equator. Because the planet has an internal heat source, and because it's spinning on its axis so fast, the changes you'll see in a telescope are rapid and dramatic.

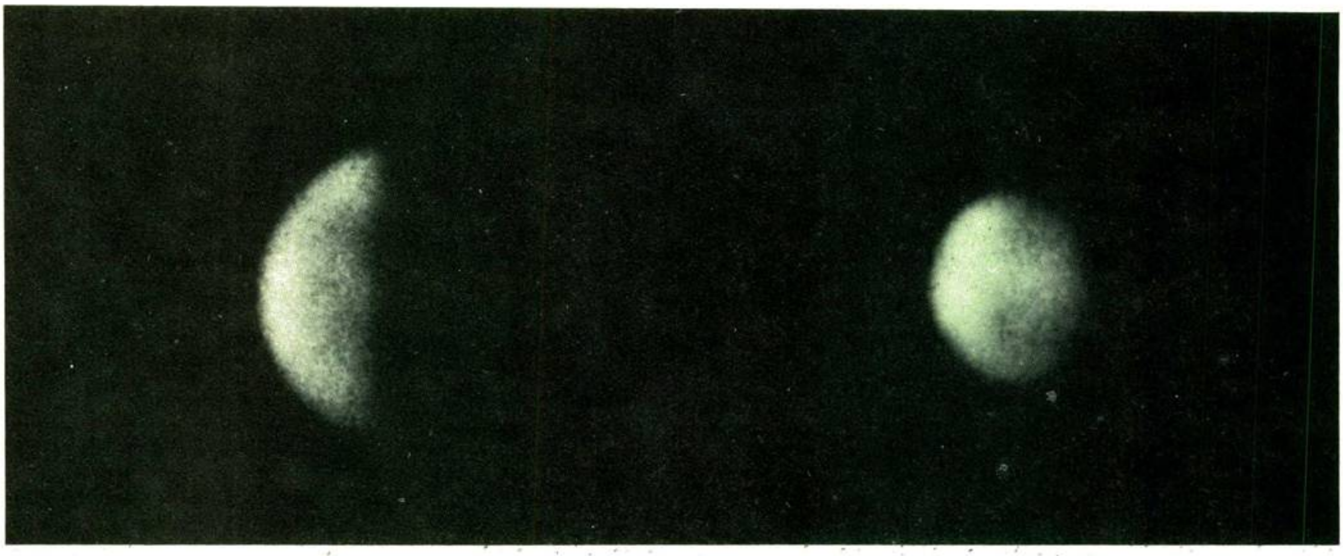
The rotation period is just less than 10 hours, causing the planet to flatten visibly at the poles. Only an hour's observation will show new expanses of belts appearing from around the eastern limb.

Sketching belt details is fun, but nerve-wracking: You have to work quickly and accurately. Accordingly, your first Jupiter sketches won't be worth a great deal, unless you've practiced a lot on other planets before you tackle it. But be sure to save them anyway — you may have noticed something important — and in any case, you'll get a kick out of them later!

One prerequisite of an accurate sketch is to have a true representation of the oblate disk. Many observing manuals will tell you how to draw the ellipse by fooling around with two pins and a bit of string, or how to trace a printed pattern. Don't bother. Go out to a drafting or art supply house and purchase a 70 degree ellipse template having ellipses of about an inch or two in size on it. The 70 degree ellipse isn't exact, but close enough and certainly better than a circle or a fudged oval! Just trace the ellipse with the template and you're in business.

As you work in the details of the cloud belts, try to see if you can detect colors. Some people find it easy; others find it hard. The colors, which do exist, are pastel and not at all "saturated," so be careful. Make notes on your sketch, but don't try to use colored pencils until you've gained a *lot* of experience.

Be sure to look for the famous Great Red Spot, but don't despair and hock your telescope if you don't see it! It may just be on the other side of the planet when you observe, or it may have faded



The above photographs of Mercury, taken with a large telescope, show the greatest amount of detail which an experienced planetary observer might be able to discern with a moderate-size aperture under good conditions. Usually only a featureless surface is seen, though sometimes faint dusky markings such as these are visible. Compare these photographs with the images on pages 16-17, returned by a deep space probe!

away. The Red Spot does seem to "disappear" at times, and this is one important scientific reason to patrol the planet Jupiter.

Saturn

Saturn is like Jupiter, except that it's only about half the apparent size at maximum, and the cloud belt details are very understated compared to the Jovian ones. They're so weak you'll probably find it hard to see anything at all to start with, but keep at it.

As if to make up for the pallid disk, Saturn presents the spectacle of the rings. During 1979, Earth passes through the plane of the rings, making them disappear from sight. The passage happens in October of this year, and close monitoring of the rings' appearance will be fun. As with the other planets, you can draw a sketch — or simply note the dates on which the rings seem to vanish and then reappear.

Drawing a blank for Saturn is more difficult than for Jupiter, primarily because of the rings' varying aspect. Saturn is even more oblate (flattened) than Jupiter, which will be apparent to anyone with a telescope this year, when we see the planet in the plane of its equator. If you want to get a template for Saturn, buy one for 60 or 65 degrees. These are not exact, but close enough.

You'll find that details are hard to see on Saturn. For one thing, we're at a great distance from it, and also the planet seems to be just less active than Jupiter. Look for variations (in brightness and color) in the belts. Occasional white spots are seen and the rings sometimes appear to have nonsymmetrical variations in brightness from place to place on them.

Another thing to look for is the Cassini division. Saturn actually has *three* main distinct rings, separated by two gaps or divisions. The Cassini division, separating the outermost from the middle ring, is the wider of the two. The narrower Encke division, which divides the middle ring from the faintest so-called "crepe" ring, will be much harder to see. Also note (if you can) the shadows cast by Saturn onto the rings, and by the rings onto Saturn.

Uranus and Neptune

When you try to observe Uranus and Neptune, you're really pushing your instrument to the limit. These great gas giant planets are so far away and so dim that little detail is seen even in the largest telescopes.

Uranus looks definitely nonstellar with medium powers and seems to have a greenish cast. Neptune needs a higher power to show a disk at all and appears essentially grey.

Be content with locating Uranus and Neptune in your telescope — that's more than you'll probably achieve with Pluto!

Pluto

Forget it! Even though Pluto is moving in towards perihelion, it's at 14th magnitude, so you won't see the planet in anything less than an eight inch telescope. Even if your instrument is capable of detecting it, merely locating the tiny speck of light would be a matter of finding the proper field, mapping it (by hand or by camera), and comparing your map with the field a few days later. Besides, we're no longer sure Pluto even deserves the title of "planet" any more. (See **ASTRONOMY**, December 1978.) Save your energies!

Planetary Satellites

Throughout this article, we've made no mention of the planets' satellites. The chief reason is that all of them look stellar, unless you're using a scope 12 inches or more in aperture. But don't let this stop you from trying to see how many of Jupiter's 13 (or maybe 14!) satellites you can see. Finding the fainter ones is like locating Pluto: Map, then compare.

Patrolling the planets is an enjoyable way to learn about them, sharpen your skills and keep a scientific eye on the solar system. As you get more practiced, your sketches and eyesight will become more acute. Before you know it, you'll look back at your first efforts with amazement, and, we hope, at least a little pride. You'll soon see that there's no secret to being a skilled observer — just practice!

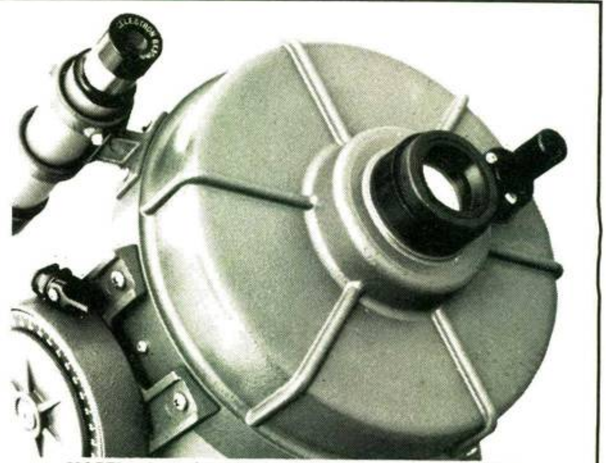
ALPO

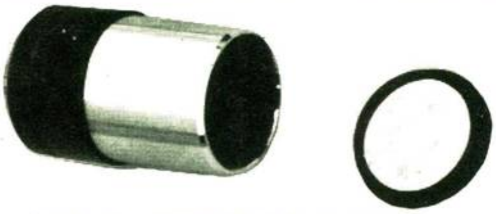
The Association of Lunar and Planetary Observers (ALPO) is a national amateur organization which promotes and coordinates observations of solar system members, including comets and asteroids as well as the moon and planets. There are individual sections each devoted to watching a particular planet or class of objects, and a special lunar and planetary training program is offered for novices. The Association publishes a journal on an irregular basis — usually appearing at three to four month intervals — called **The Strolling Astronomer**. The subscription rates are $8 for 6 issues and $14 for 12. Subscription and membership information is available by writing to **The Strolling Astronomer**, Box 3AZ, University Park, N.M. 88003.

LPR FILTER

THE CELESTRON LIGHT POLLUTION REJECTION FILTER
THE ASTRONOMER'S DREAM COME TRUE

- Makes bright light polluted skies appear dark by rejecting radiation from mercury and sodium lights.
- Makes dark sky locations appear even blacker by rejecting unwanted natural light (nightglow, interplanetary light, and integrated starlight) caused mainly by neutral oxygen emissions.
- Allows maximum transmission of the important wavelengths of Hydrogen Alpha, Hydrogen Beta, and Doubly Ionized Oxygen.
- It's no longer necessary to make long drives into the country to seek dark sky observing sites. It makes deep sky objects visible from city locations. The views are spectacular whether using small or large aperture.
- Although its startling performance is most pronounced when observing nebulae, it will also significantly improve your views of galaxies and star clusters with associated nebulosity.
- Affordability. Due to the latest advances in the state-of-the-art coating processes and the mass production techniques of Celestron, the filter can be sold at a popular price.
- Allows educators to show students deep-sky objects previously invisible from many urban campuses.
- Durability. The multi-layer dielectric coating needs no special care or protection and with normal handling will last many, many years.
- And at last, deep sky astrophotography in the city from your backyard.


MODEL #1 — SHOWN ATTACHED TO C8 TELESCOPE


MODEL #4 — SHOWN NEXT TO AN 1¼" OCULAR

AVAILABLE IN THE FOLLOWING MODELS

Model #1 — $100.00 Available for C5 and C8 models for both visual and photographic uses. Mounted in a special cell that threads on the back of the Celestron and accepts the Visual Back (.96" or 1¼") or the Off-Axis Guider. You then use your standard oculars and photo accessories at random. In addition, the 2" Diagonal and 2" oculars for the C5 and C8 are compatible with this model. This model may also be used on the C14 when using the 1¼" oculars. However, if you desire to use 2" oculars on the C14 you should obtain Model #2.

Model #2 — $250.00 Available for the C14 Telescope. Mounted in a special cell that threads on the back of the C14 and allows you to use any photo or visual items of Celestron manufacture including the 2" oculars.

Model #3 — $85.00 Available for the C90 Telescope. This filter is a screw-in type for .96" (24.5mm) dia. oculars. This model can be used on the C5 Telescope for visual use only with .96" (24.5mm) dia. oculars. In addition, this model can be used with other manufacturer's .96" (24.5mm) dia. oculars that have a thread-in capability.

Model #4 — $90.00 A 1¼" dia. screw-in type filter for Celestron oculars and most other manufacturer's oculars of 1¼" dia. that have a thread-in capability.

Model #5 — $150.00 A 2" dia. screw-in type filter for Celestron 2" oculars and other manufacturer's oculars of 2" dia. that have a thread-in capability.

TYPICAL CHARACTERISTICS OF THE LPR

Desirable Transmission Lines:
- (C) 4861 — Hydrogen Beta
- (D) 4959 — Doubly Ionized Oxygen
- (E) 5007 — Doubly Ionized Oxygen
- (L) 6563 — Hydrogen Alpha

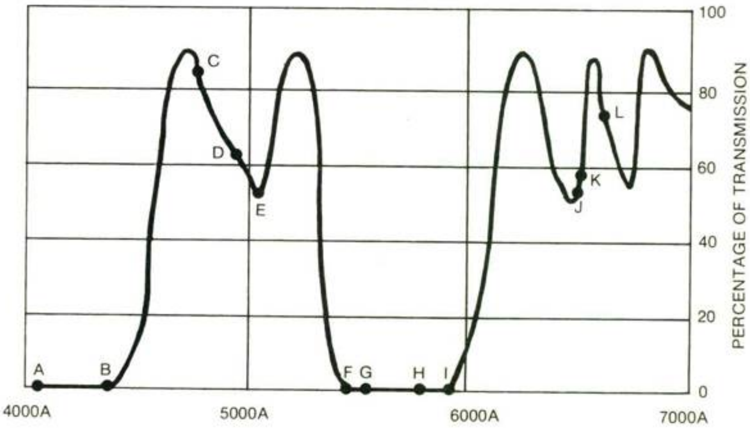
Rejection Lines:
- (A) 4047 — Mercury
- (B) 4358 — Mercury
- (F) 5461 — Mercury
- (G) 5577 — Neutral Oxygen
- (H) 5790 — Mercury
- (I) 5890 — Sodium
- (I) 5896 — Sodium

Partial Rejection Lines:
- (J) 6300 — Neutral Oxygen
- (K) 6360 — Neutral Oxygen

Average Transmission of
Stellar Sources — 70%

Rejection Ratio — 461:1

TYPICAL CELESTRON LPR FILTER SPECTRAL RESPONSE



Celestron International 2835 Columbia St., Box 3578B, Torrance, California 90503. Telephone (213) 328-9560

Guide to Back Issues

– $2.50 each –

August 1973: FIRST ISSUE. "Hour of the Midday Night" (solar eclipses); "In Search of Planet X"

July 1974: "Astronomy from Skylab"; "What Radio Eyes Would See"; "An Introduction to Small Telescopes"

January 1975: "Beyond the Milky Way"; "Saturn – The New Frontier"; "Getting to Know Your Telescope, Part 1"; "Why Does the Crab Nebula Shine?"

May 1975: "The Search for Intelligence"; "Countdown to 2001"; "Comet Exploration from Space"

June 1975: "From Dust to Dust" (stellar evolution); "The Changing Surface of Mars"; "The Realm of the Galaxies"; "Rich Field Telescopes"

July 1975: "The Quest for Life on Mars"; "The Age of Nearby Stars"; "Mysteries of the Galactic Core"

August 1975: "Showers of Fire" (meteors); "Faster Than Light?" (quasars)

September 1975: "Baptism of Fire" (meteor craters); "The Quasar Dilemma"; "Cosmic Rays"; "Let's Take a Look at the Sun...Cautiously"

October 1975: "Aurora"; "Starspots on Betelgeuse"; "Shape of the Milky Way"

November 1975: "Big Bang to Galaxy"; "Mars' New Frontiers"; "Two X-Ray Stars"

December 1975: "Astronomy From the Moon"; "The Planet Mercury"; "Tune Up Your Telescope" (collimating optics)

February 1976: "Io"; "Exploding Stars"; "How Far Is Up?" (stellar distances); "The Gibbous Moon"

March 1976: "Beyond Space Shuttle"; "Whispers of the Cosmos' Birth" (cosmic microwave background); "Infrared Astronomy"; "Life's Protective Shield" (magnetic field reversal)

April 1976: "Finding Unseen Worlds" (astrometry); "Dust Clouds and Ice Ages"

May 1976: "Quasars: Oddities of Space"; "Cosmic Explosions"; "Molecules of Life" (interstellar molecules); "Choosing B&W Films"

June 1976: "Asteroids"; "Viewing the Full Moon"; "What You Can See Through a Small Refractor"; "Setting Up an Astrodarkroom"

– $3.50 each –

July 1976: SPECIAL ISSUE (32 extra pages!). "The History of American Astronomy"

– $2.50 each –

August 1976: "Venus"; "Viking Orbits Mars"; "Clusters of Galaxy Clusters"; "Exploring the Milky Way, Part 1"; "Red Light Sky Photography"

September 1976: MOON ISSUE. "The Moon's Early History"; "Science on the Moon"; "The Last Quarter Moon"; "Man Looks at Mars"; "Developing B&W Astrofilms"

October 1976: "Radio Interferometry"; "Searching for Mars on Earth"; "Birthplaces of Stars"; "City Astrophotography"

November 1976: "The Space Telescope"; "Black Holes, White Holes and Wormholes"; "Doubles, Binaries and Multiple Stars"

December 1976: "The Magellanic Clouds"; "Radar Astronomy"; "Red Giant Stars" "Printing Your Astrophotographs, Part 1"; "The Messier Catalog"

– $2.00 each –

January 1977: MARS ISSUE. "Viking on Mars: Exciting Results"; "Life on Mars: Ambiguous Results"; "Printing Your Astrophotographs, Part 2"; "Exploring the Milky Way, Part 2"

February 1977: "Uranus and Neptune"; "Pluto"; "Miniblack Holes"; "Observing Saturn"; "Cold Cameras, Part 1"

March 1977: "Phobos and Deimos"; "New Color Photos of Galaxies"; "Duststorms of Mars"; "Cold Cameras, Part 2"

April 1977: "Supernovae!"; "Astronomers in Space, Part 1"; "Printing Your Astrophotographs, Part 3"; "Building A 6" Reflector, Part 1"

May 1977: "The End of Time"; "Can Life Evolve in Elliptical Galaxies?"; "Building A 6" Reflector, Part 2"; "Astronomers in Space, Part 2"

June 1977: "Gamma Rays and the Origin of Cosmic Radiation"; "A Second Ringed Planet"; "Beginning With Your Telescope"; "Observing With Binoculars"

July 1977: "The X-Ray Universe"; "What Makes Novae Blow Up?"; "Astrophotography With Telephoto Lenses"

August 1977: "Slow Boat to Centauri" (interstellar travel); "Probing the Nearest Star"; "Building A 6" Reflector, Part 3"

September 1977: "Stars With Companions"; "Robot Probes"; "Between Stars and Space"; "Building A 6" Reflector, Part 4"; "Light Pollution"

October 1977: MARS ISSUE. "The Polar Regions of Mars"; "Martian Climate"; "Buyers Guide to Small Telescopes"

November 1977: "The Revolution in Astronomy"; "The Southern Sky"

December 1977: "Why Do Planets Have Rings?"; "Tunguska – Collision With a Comet"; "Learning the Constellations, Part 1"; "Printing Your Astrophotographs, Part 4"

January 1978: "Our Sun"; "Photographing the Sun in H-Alpha"; "Observing Herschel Objects"; "Building A 6" Reflector, Part 5"

February 1978: "The Shaky Machine"; "Why Does Earth's Climate Change?"; "Photograph the Moon!"; "What You Can See Through A 6" Telescope"

March 1978: "Swarms of Stars: Cosmic Calibrators"; "Rival Cosmologies"; "Isophote Mapping"; "What's Inside Your Telescope? Part 1"

April 1978: "Beyond Centauri"; "Brown Dwarfs and Black Holes"; "What's Inside Your Telescope? Part 2"; "Learning the Constellations, Part 2"

May 1978: "Terraforming"; "Blink for a Nova!"; "Celestial Software, Part 1"; "The 'Big Four' Asteroids"

June 1978: "Astronomical Spectroscopy"; "Solar Eclipse '79"; "Astrophotography – With Camera Only!"; "Gravity, Dust and Solar Neutrinos"

July 1978: "Red Dwarf Stars"; "What's Inside Your Telescope? Part 3"; "Are Galaxies Here to Stay?"; "Celestial Software, Part 2"; "Learning the Constellations, Part 3"

August 1978: EARTH ISSUE. "The Early History of Planet Earth"; "Our Dynamic Planet"; "Earth's First Oceans"; "What's Inside Your Telescope? Part 4"

September 1978: "The Redshift Problem"; "The Dark Sky Paradox and the Origin of the Universe"; "Celestial Software, Part 3"

October 1978: "Are Black Holes Really There?"; "The New Era in Ultraviolet Astronomy"; "Learning the Constellations, Part 4"

November 1978: ECLIPSE ISSUE. "Asteroid Mining"; "Observing Earth From Space"; "Why Go to a Solar Eclipse?"; "Film the Eclipse!"; "Winterize Your Expedition"

December 1978: "Pluto – Planet or Impostor?"; "U.K. Schmidt Pictorial"; "Watching the Inner Planets"

January 1979: "Are We The Only Intelligent Life In Our Galaxy?"; "Is There A New Lunar Crater?"; "Photographing Star Clusters"

February 1979: "Stellar Evolution"; "The Sun Will Darken!"; "Eyepieces: What You Get Is What You See!"; "A New Revolution in Solar Physics"

March 1979: "The Grand Adventure" (space exploration); "Planetary Nebulae, Part 1"; "Nebular Filters"; "Patrolling the Planets"

For Postage & Handling:
U.S. – Add $1.00 per order
Canada/Mexico – Add $2.00 per order
All Other Foreign – Add $2.50 per order

– $2.50 each –
August 1973 ______
July 1974 ______
January 1975 ______
May 1975 ______
June 1975 ______
July 1975 ______
August 1975 ______
September 1975 ______
October 1975 ______
November 1975 ______
December 1975 ______
February 1976 ______
March 1976 ______
April 1976 ______
May 1976 ______
June 1976 ______

– $3.50 each –
July 1976 ______
– $2.50 each –
August 1976 ______
September 1976 ______
October 1976 ______
November 1976 ______
December 1976 ______
– $2.00 each –
January 1977 ______
February 1977 ______
March 1977 ______
April 1977 ______
May 1977 ______
June 1977 ______
July 1977 ______
August 1977 ______

September 1977 ______
October 1977 ______
November 1977 ______
December 1977 ______
January 1978 ______
February 1978 ______
March 1978 ______
April 1978 ______
May 1978 ______
June 1978 ______
July 1978 ______
August 1978 ______
September 1978 ______
October 1978 ______
November 1978 ______
December 1978 ______
January 1979 ______
February 1979 ______
March 1979 ______

Send check or money order to:
ASTRONOMY
411 E. Mason St.
P.O. Box 92788
Milwaukee, WI 53202

Date: ______

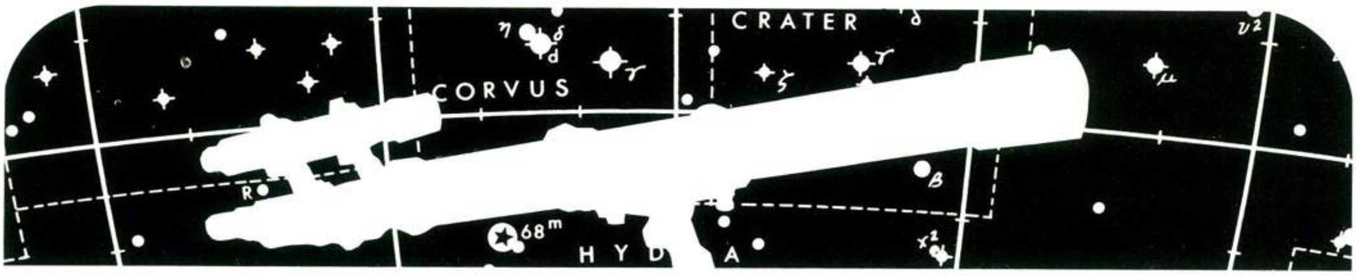
Total enclosed: $ ______ Payment must accompany your order.

Name ______
(please print)

Address ______

City ______ State/Prov. ______ Zip ______

Please remit in U.S. funds or equivalent. Allow 6-8 weeks for delivery



Nebular Filters

by
Richard Berry

Nebular filters appeared on the telescope accessory market only six months ago, and today seem to be one of the more popular topics whenever a group of astronomy enthusiasts gathers to talk. But what is all the talk about? What do these filters do? How do they work? And do they work as well as claimed?

Nebular filters are *interference filters* made by coating many optical layers on a piece of glass. They are designed to block light from man-made sources (such as streetlights) while transmitting light from nebular objects in the sky. The filters are usually screwed into the barrel of the eyepiece, but can also be held behind the eyepiece. Do they work? The answer is: "Yes, they do — providing they are used for the right kind of object with the right kind of telescope."

How do they work?

You don't have to understand the physics of interference filters to see how they work, but it helps you to understand their pricing if you appreciate the complex vacuum coating technology that goes into them.

Imagine that you built a thick cake consisting of dozens of layers of icing and frosting — alternating light, fluffy layers with dense, gooey layers — then shrank it down until the layers were as thick (approximately) as a light wave. Now in your imagination, shine a beam of light into this confectioner's delight. Each time the light hits a change in layer type, some of the beam is reflected backwards and some goes through. The same thing happens with an ordinary glass window. But let's say that you want your cake to act like a mirror for a certain wavelength of light: You then carefully arrange the spacings of the layers (that is, you put on thicker or thinner layers of frosting) so that all the partially reflected beams of your particular wavelength of light add together. At the same time, all the beams transmitted out of step may be weakened. Light of the particular wavelength you designed your cake for is mostly reflected, so it acts like a mirror — at that one wavelength. Light at a different wavelength won't be reinforced when it's reflected, however, and may be transmitted if the light that goes through each layer adds together. By building a very complex cake with many layers of different but precisely correct thicknesses, you could make *a device that acts like a mirror for some light, and acts almost like a piece of clear glass for others.*

Using dielectric materials such as magnesium fluoride (familiar to camera buffs as a blue sheen on their lens) and various metal oxides, fluorides, bromides and iodides, filter makers build up complex stacks of layers on glass blanks. These versatile filters can transmit very narrow bands of just one wavelength, reflect visible light but not infrared or be tailored to transmit light from nebulae but not from streetlamps.

What is light pollution?

Streetlights are the major cause of light pollution. Most streetlamps contain either mercury vapor, sodium vapor at low pressure or sodium vapor at high pressure, though there are still a few incandescent streetlights around. You can recognize mercury lamps easily: They look blue. Low-pressure sodium lamps look bright yellow, but high-pressure sodium lamps appear pinkish-white. Incandescent lights look like ordinary light bulbs. Each type of lamp emits a distinct group of wavelengths. Mercury and low-pressure sodium lamps are fairly easy to deal with because they emit a small number of discrete lines; high-pressure sodium and incandescent emit over broad areas of the spectrum. To some extent, the best filter for you depends on how many of each kind of lamp are in your area.

The most important man-made lines to block are the 4047, 4358, 5460, and 5790 Angstrom lines from mercury lamps and the 5890 and 5896 lines of sodium. Good filter blockage should eliminate most of the broad emission from high-pressure sodium lamps extending from about 5600 to 6200

Nebular Filter Suppliers

Astro-Engineering
437 W. 19th St.
Costa Mesa, Calif. 92627

Cross Optics
P.O. Box 27292
Escondido, Calif. 92027

Celestron International
2835 Columbia St.
Torrance, Calif. 90503

L. Henzl & Associates
P.O. Box 7000-38 T
Rolling Hills, Calif. 90274

Meade Instruments
721 W. 16th Street
Costa Mesa, Calif. 92627

Star Instruments
17972 Skypark Circle, Suite K,
Irvine, Calif. 92714

Star Quest Enterprises
378 South Tustin Avenue
Orange, Calif. 92666

Filter Specifications

Transmission of Nebular Lines

	Celestron	ASTRO-ENGINEERING	Daystar 300	Daystar 500
4861 H-beta	79%	76%	94%	94%
4959 oxygen	73%	75%	93%	95%
5007 oxygen	56%	74%	91%	94%
6563 H-alpha	62%	80%	45%	83%
green bandpass	510	580	290	550 Angstroms
Light Pollution Transmission				
Mercury				
4047	small	—	22%	1%
4358	small	under 1%	small	small
5460	small	small	small	small
5790	under 1%	under 1%	small	small
Sodium				
5890/96	0.6%	0.5%	small	small
5600 continuum	small	small	small	small
6200 continuum	70%	43%	1%	small
Natural Light				
5577	small	small	small	small
6300	50%	14%	6%	under 1%
6360	63%	30%	20%	1.5%

Sample filters and data were provided by the manufacturers.

Angstroms. In addition, under dark skies it's useful to have a filter that can block the 5577 Angstrom line of oxygen (the reason most aurorae are green) and the 6300 and 6360A lines (which sometimes color aurorae red). These lines in the natural night sky are always present — though weak — even when aurora is not.

What is nebular light?

Gaseous emission objects are the familiar objects you see in color deep sky photographs as red. They consist of glowing clouds of gas in space, heated and shining because of hot stars within them. The Orion nebula, the Lagoon, the Eagle, the Ring, the North America, the Owl, the Dumbbell, the California and the Veil are all nebulae of this type. Other objects called nebulae (such as the Andromeda nebula) are not gas nebulae at all; they are galaxies. Some nebulous objects are reflection nebulae; notable among them is the nebula that envelops the Pleiades.

The strongest wavelengths given off by these nebulae are the hydrogen lines at 6563A (H-alpha) and 4861A (H-beta). In addition, two strong oxygen lines, one at 5007A and the other at 4959A, are important. Two nitrogen lines at 6548A and 6584A add a bit more to the red. One of the very strongest lines, 3727A (due to oxygen), is invisible to the human eye, and another good one (H-gamma) at 4340A, lies in a region of low visual sensitivity. A helium line at 5876A is too close to the mercury and sodium light pollution lines to be useful, and the next good helium line lies in the near infrared. Thus all the good lines are clustered in the blue-green part of the spectrum near 5000 Angstroms or in the red near 6563 Angstroms, while the worst light pollution lies in the yellow and yellow-green region of the spectrum.

What filters are available?

Of the filters on the market and tested by ASTRONOMY, two are made by Daystar Filter Corp. (sold by L. Henzl & Associates), and one made by Cascade Optical Coating and sold by several firms. Several other companies will be offering filters in the near future, so our listing cannot claim to be exhaustive or complete. Furthermore, all of the filters are undergoing vigorous development efforts, and are likely to have better specifications and lower price tags in the future, much as has happened in the pocket calculator market.

Observing with a nebular filter

When you first try a filter, you will probably want to hold it so that you can quickly look through the telescope with it and then without it — just to see what effect it has. Your reactions on that first trial could range from great excitement to great disappointment, depending on how realistic your expectations are.

All filters *remove* light from an image — they never *add* light — so remember that any improvements brought about by nebular filters happen because less artificial light comes through. This tends to increase the contrast of the nebular image. Moonlight and light from incandescent lamps will not be affected. Remember that galaxies, stars, clusters and non-gaseous nebulae are barely enhanced — but *always* made dimmer. Gaseous nebulae are generally improved because they stand out better against a blacker sky.

Here's roughly what you can expect to see (depending, of course, on your local observing conditions) with a number of different types of instrument:

With a small RFT: The background sky is cut back markedly at low powers, but far less obviously at higher powers. Objects like M-27 and the Lagoon are much easier to find under badly polluted city skies and show greater extent under suburban skies. Under moderately dark country skies, the North America nebula, the Rosette and the Veil are markedly enhanced — the filter can make the difference whether you find such objects at all. Nebulae with small angular diameters (i.e., those normally viewed under high power), are not enhanced much at all, nor are galaxies or star clusters noticeably improved.

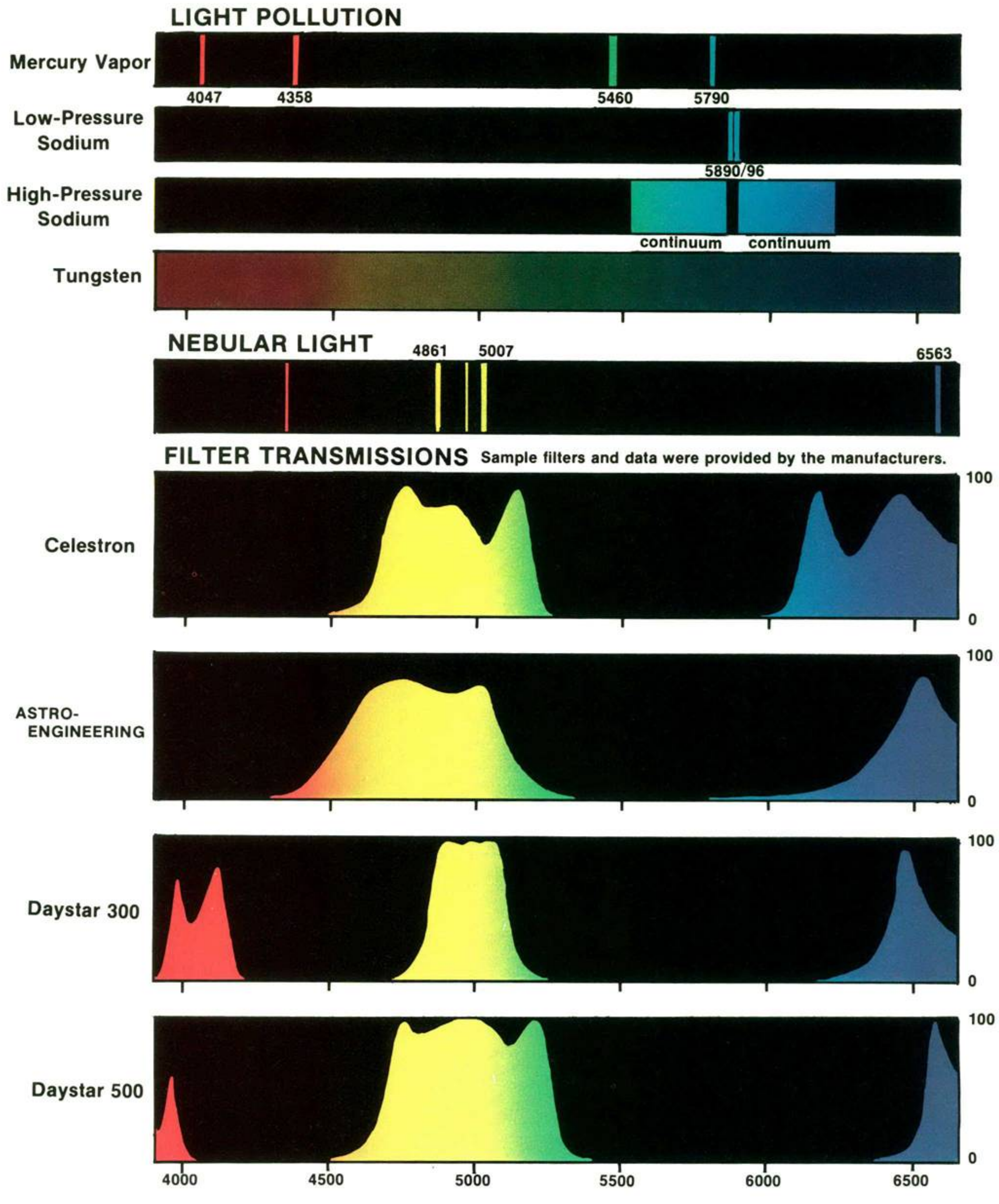
With a small refractor: Because small refractors are seldom used at very low power (a 2.4 inch refractor would be an RFT if it were used with an eyepiece giving about 10 power), the brightness of the sky background is already low; nebular filters can reduce it somewhat more, but never with spectacular results because the field is dark to begin with.

With a 6 to 10 inch: A filter enhances all of the larger and brighter gaseous nebulae, the effect being particularly nice on the larger and brighter ones such as the Orion nebula. Marginal objects like the Crab and the Dumbbell may show detail instead of appearing as faint shapeless glows. Big gaseous nebulae such as the North America nebula won't fit in the field, but the Veil is detectable under suburban skies.

12 inch and larger: The happiest users of nebular filters may be the owners of large and very large telescopes, providing they use the telescope at very low powers (4 to 8x to the inch). With a 14 inch Newtonian from a city sky, for example, a filter brings out sweeping side-lobes on the Orion nebula which cannot be seen without it. The Horsehead, which is both small and faint, is fair game from the suburbs.

What to look for in a nebular filter

What should you look for in comparing the specifications of various nebular filters? First, look for adequate blockage of artificial light. If you have lots of high-pressure sodium lamps in your area, be especially sure that you get good blockage of the broad continous emission of that type of lamp.



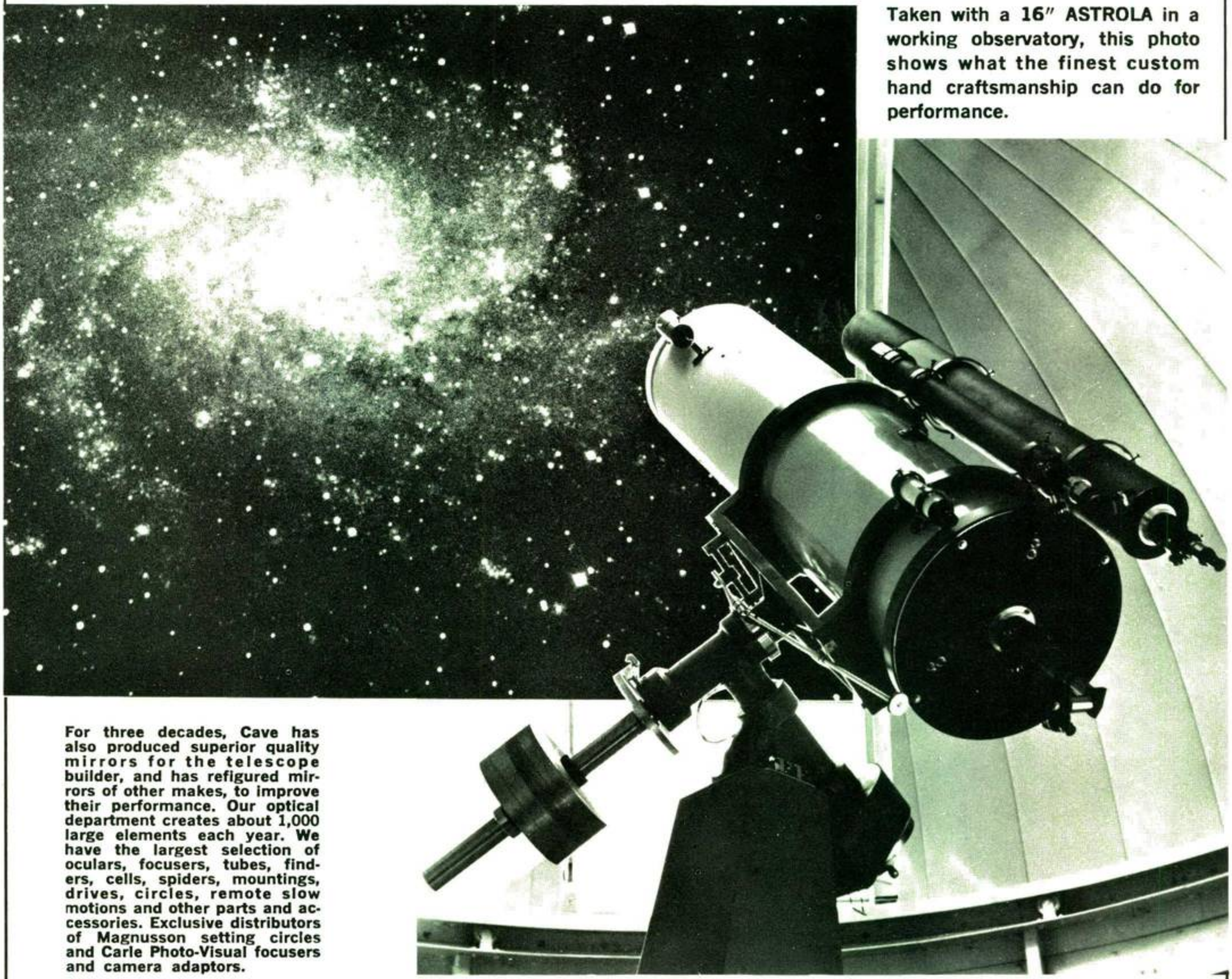
Next, look for high transmission of the nebular lines — the higher the better. Remember that the most important lines are those that fall in areas of high spectral sensitivity of the eye, especially the 5007 line and H-beta at 4861 Angstroms.

If you live in a city where there is a lot of light pollution, you might bias your choice toward a filter that does especially well at blocking background light, even to the extent that transmission of some lines is low. If you live in the suburbs, blocking is relatively less important. There, moderately good blocking and high transmission is what you want most. If you live far from city lights, high transmission and blocking of natural background lines is crucial.

Finally compare prices and specifications, then try to make the best decision for you and your telescope. After testing many filters, you will find that they all work, at least to some extent. Because the filters available are evolving so quickly, you may want to ask for more information and specifications before you order. And if you're dubious, wait a while or borrow somebody else's for an evening and try it out — then if you like what it does, order one.

Cave ASTROLA

CUSTOM-MADE AMERICAN TELESCOPES WILL OPEN NEW DOORS TO VIEWING PLEASURE



Taken with a 16″ ASTROLA in a working observatory, this photo shows what the finest custom hand craftsmanship can do for performance.

For three decades, Cave has also produced superior quality mirrors for the telescope builder, and has refigured mirrors of other makes, to improve their performance. Our optical department creates about 1,000 large elements each year. We have the largest selection of oculars, focusers, tubes, finders, cells, spiders, mountings, drives, circles, remote slow motions and other parts and accessories. Exclusive distributors of Magnusson setting circles and Carle Photo-Visual focusers and camera adaptors.

You won't see any assembly lines at Cave. What you will see is a beautifully equipped optical department, grinding and finishing the finest possible mirrors and lenses . . . skilled craftsmen, turning out hand-finished, custom telescopes. We produce more 8, 10, 12 and 16-inch Newtonians than anyone in the world, but each instrument is assembled with painstaking care for a discriminating customer. This has been going on for almost thirty years.

ASTROLA owners, world wide, know that a Cave craftsman never hurries at the sacrifice of quality. That quality means top performance. Because we build more than 40 different models of our own design, from 6-inch through 16-inch aperture, there is a Cave ASTROLA to fit your particular telescope need and budget. Extended payment terms are available. Visa or Master Charge may be used.

Before you make an important purchase decision, or buy an imported off-the-shelf telescope, don't you owe it to yourself to review our complete custom line?

If you live in the United States, send $1.50 (if outside the U.S., $3.00) for your ASTROLA color catalog. Sorry, we can accept only U.S. currency, your check, or a negotiable money order—no stamps or coupons. Your catalog will contain a current price list, and complete mechanical and performance specifications for each instrument. Catalogs are sent by air. Write or call for yours today!

Our factory showroom, featuring a complete selection of astronomical instruments, parts, accessories and literature, is open Tuesday through Saturday, from 9 A.M. to 5 P.M.

CAVE OPTICAL COMPANY
4137 E. ANAHEIM STREET
LONG BEACH, CALIFORNIA 90804
Telephone 213-434-2613

ASTRO-NEWS

Latest News From the World of Astronomy

Tight Budgeting Imposed On New NASA Programs

The budget requested by NASA for fiscal year 1980 includes no provision for new program starts. This may mean a severe cutback in future years as well because of several factors, according to informed sources.

The postponement of several planned program starts will bring them into conflict with others tentatively scheduled for start-up in later years. A notable example is the Venus Orbiting Imaging Radar (VOIR) mission, originally planned for initial funding this year in preparation for an already-postponed 1984 launch date. The 1984 date can still be met with a start-up in the fiscal year 1981 budget, but that will bring VOIR into direct competition with a planned mission to Halley's Comet and comet Tempel 2. It may prove difficult to obtain start-up budgetary approval for two such major missions in a single fiscal year.

But neither program could be effectively delayed any longer. Scientists agree that a comet rendezvous is essential for a better understanding of comets, but NASA has already had to drop plans for a rendezvous with Halley's Comet as too expensive. Instead, a probe would be dropped into the comet's tail while the main spacecraft continued on for a later rendezvous with comet Tempel 2. But such a two-for-one mission is possible only with a 1981 start. If postponed, the objectives of the mission could only be met at the price of doubling the mission — and the cost: Two separate spacecraft instead of a single one would be necessary.

As for the VOIR mission, any further delay would prevent use of the 1984 launch window, and the next opportunity will not come until 1991.

Another problem faced by NASA is a surprise ceiling set by the Office of Management and Budget (OMB) on NASA's Office of Space Science. The OMB has said that no more than $600 million should be spent on space science each year. Upset NASA officials claim that President Carter's announced space policy did not set such artificial budgetary ceilings, but rather called for evaluation of programs on the basis of scientific merit.

Another planned request which had to be dropped for fiscal 1980 was the development of a high-power module for the Space Shuttle program. Such a module would enable greater versatility and longer operation times for Shuttle missions. Starting it in fiscal 1981 will bring it into direct competition with plans for a increased thrust system for the Shuttle, and may force cutbacks in both programs.

Finally, the difficulties in the immediate future may cause problems with missions farther down the line. Currently under study are several follow-up Mars missions, to be started in fiscal year 1982. Two main programs are being considered: a multisite sample return and a geoscience/aeronomy orbiter.

The multisite sample return, planned for launch in 1988-1990, would consist of four landers, each of which would be targeted for one of the major geologic provinces on Mars. Each lander would include a rover dedicated to sample collection, sample selection instruments, sample collection tools, and a scientific package to be left on the surface. In addition there would be a science orbiter instrumented to obtain data on global chemistry, mineralogy, and magnetic and gravity fields, as well as an increased understanding of the composition and dynamics of the martian atmosphere.

No decision has yet been reached on the most desirable range of mobility for the surface rovers. Ideas about proper mobility range from a few feet to over a hundred miles.

A more modest option for a martian mission is the geoscience/aeronomy orbiter. To be launched in 1986, the orbiter would focus on much narrower objectives than the sample return mission. However, it is expected to provide important understanding of the surface distribution of martian geochemical and geophysical provinces, as well as a more detailed picture of the chemical and dynamic processes that operate in the martian atmosphere.

However, the current budgetary restrictions and start-up delays may make the decision of which martian mission to approve a moot point. A Mars mission is third priority after VOIR and the comet spacecraft. But if the Venus follow-on mission fails to receive its last chance for approval for fiscal year 1981, it could make a martian start-up possible in 1982 — *provided* budgetary restrictions are not further tightened.

On the basis of current tendencies, some space scientists fear that America's exploration of the solar system may be winding down to a close. Ironically, 1978, NASA's 20th anniversary year, was one of the agency's most successful, highlighted by the two Venus missions!

Other important launches included the second High Energy Astronomy Observatory (dubbed the Einstein Observatory), the International Sun-Earth Explorer 3, and the first International Ultraviolet Explorer — these last two in cooperation with the European Space Agency.

Altogether, NASA conducted 20 launches last year, mainly for other organizations or agencies. It was the third year in NASA history with a 100% launch success record.

Russian Probes Land on Venus

A thunderous environment was revealed by two Russian space probes which descended through the dense, poisonous atmosphere of Venus to make soft landings on its hot, rocky surface last December. The two landers, arriving on Dec. 21 and Dec. 25, beamed back information for a total of 205 minutes before succumbing to the harsh surface conditions.

A number of particularly violent electrical discharges were detected as each of the two craft passed down through Venus' atmosphere, and Venera 12 recorded one discharge after its landing which "made the surroundings resound for 15 minutes," according to the official Soviet release.

The first probe to land, Venera 12, was the second to be launched but arrived before Venera 11 because of its faster trajectory, covering 149 million miles in 98 days. It was the ninth Soviet probe to land on the rocky surface, and it relayed data on the composition of the atmosphere and clouds during its parachute-assisted descent.

After landing successfully right on schedule, scientific measurements continued to be transmitted for an additional 110 minutes.

The second probe to land, Venera 11, survived for 95 minutes on the surface. The temperature at the Venera 11 site was recorded at 835° Fahrenheit (446° Celsius), while that at the Venera 12 site was 860° Fahrenheit (460° Celsius). According to the official Soviet press release, the two identical probes had been designed to last at least 30 minutes after landing, and to photograph the Venusian surface. It was not reported, however, whether any photographs had in fact been received. Two earlier Russian craft, which landed in October 1975, provided the first — and so far only — panoramic television views of the landscape.

Both surface probes landed on the far side of Venus as seen from Earth now. Each had been released from a mother ship which flew on by the planet, acting as a relay station for the transmission of data from the surface landers. Nothing was placed in orbit about the planet.

Already results from the Soviet mission have confirmed the surprising discovery of earlier American probes that the abundance of argon-36 is much greater on Venus than on Earth. Preliminary Russian estimates indicate the ratio of argon-36 to argon-40 in the Venusian atmosphere is 200 to 300 times higher than on Earth, a discovery which may force significant alterations in the accepted theories of planetary formation.

The American missions Pioneer Venus 1 and Pioneer Venus 2, which reached Venus about two weeks earlier, included four atmospheric probes not designed to survive surface impact and an orbiter which will circle the planet, it is hoped, for at least 243 days. One of the U.S. probes, however, surprised and delighted scientists by continuing to relay data for an extra 67 minutes, 47 seconds after landing.

Arrangements have been made between American and Russian scientists to share the information gained from their respective Venus missions.

ADVERTISEMENT

GOOD NEWS

Due to the overwhelming response to our low prices, we have postponed our price rise on ***Celestron*** telescopes and accessories. At ASTRO ENGINEERING— prices are lower than any other ***Celestron*** dealer. We don't offer confusing package deals where you might get something you don't need. For this reason our free catalog includes the 32 page ***Celestron*** catalog. Owner's manual for any ***Celestron*** telescope free on request to help you select the telescope system best suited for your needs.

NEW PRODUCTS AND SERVICE

- 12 volt portable power pack and charger (5 amp-hrs.) . . . . $ 34.95
- Variable frequency D.C. Inverter . . . . $ 45.00

•E-6 PROCESSING•

20 & 36 EXPOSURES . . . . $ 4.95

Mounted in removable plastic slide mounts.

FREE SHIPPING IN CONTINENTAL U.S.A.
MasterCharge/VISA. Money Back Guarantee.
Write for our Free Catalog Package or
Telephone 714/646-3466

ASTRO-ENGINEERING
437 WEST 19th STREET • COSTA MESA, CA 92627

NEBULAE FILTER™

COMPARE THESE FEATURES...

- Transmits wavelengths of Hydrogen-alpha, Hydrogen-beta singly ionized Nitrogen (NII), singly ionized Helium (HeII), and doubly ionized Oxygen (OIII), all of which are found in the three classes of emission nebulae.
- Allows Deep-Sky objects to be viewed and photographed from the city and urban campuses.
- Rejects radiation from Mercury vapor and both Low and High pressure Sodium vapor lights, making light polluted skies dark.
- Blocks natural Sky Glow caused by OI emission (neutral Oxygen), making a dark sky even darker.
- Not only enhances nebulae but Galaxies and Star Clusters as well.
- The broadband (700+ Angstroms, green line) nature of our filter makes it useful for extravagant uses such as comet hunting, etc.
- The **ASTRO-ENGINEERING** Nebulae filter even enhances Auroral displays.
- Attenuates Tungsten and Lunar light pollution more than nebular light.
- Allows the astrophotographer to greatly extend the length of an exposure, previously limited by Sky Fog and Sky Glow.
- Allows Infrared photography down to 26,000 Angstroms.
- B-B multilayer dielectric anti-reflective coatings increase image contrast and light transmission uniformly over the visible spectrum, and protect the filter from chemical staining and fingerprints.
- Our Nebulae filter is computer designed to specifically meet the needs for both visual and photographic observations.
- Clear optical aperture: 23mm (Model 3)

MODEL #1 — .96" Thread-in filter —	$24.95
MODEL #2 — Series V drop-in —	$38.95
MODEL #3 — 1¼" thread-in filter —	$39.95
MODEL #4 — Series VI drop-in —	$79.95
MODEL #5 — 2" thread-in filter —	$79.95

WRITE FOR TECHNICAL BULLETIN (LPR-4)

UNCONDITIONAL 30-DAY MONEY-BACK GUARANTEE
— 3 YEAR WARRANTY —
Mastercharge/VISA/Check/Money Order/COD-Free Shipping

Earth Gets a Halo!

Although it may not deserve one, Earth acquired a halo when a NASA satellite called the International Sun-Earth Explorer-3 (ISEE-3) entered a giant "halo orbit" above the planet.

The reason for injecting the spacecraft into the halo orbit — the most unusual ever proposed for a space mission — is to further our understanding of solar-terrestrial relationships.

ISEE-3 was placed in orbit around the L-1 libration point, located between Earth and the Sun about one million miles (1.5 million km) from Earth. The L-1 libration point is just one of several such points in the Earth-Sun system. At these points, the centrifugal and gravitational forces acting on a satellite are exactly balanced. In its halo orbit around the L-1 point, ISEE-3 will be able to monitor the characteristics of the solar wind and other solar-induced phenomena such as solar flares about an hour before they disturb the space environment near Earth.

The plan to place ISEE-3 in the halo orbit was devised by Dr. Robert W. Farquhar of the Goddard Space Flight Center, Greenbelt, Maryland. According to Dr. Farquhar "The orbit has been designed to pass slightly above and below the ecliptic plane so that it will avoid excessive solar interference with spacecraft communications back to Earth stations. To a person observing ISEE-3 from our planet, it will appear to be orbiting the Sun, but it actually traces a halo above Earth."

ISEE-3 is unique in being the first spacecraft placed in orbit around a mathematical point in space rather than a physical body. Of course, the Lagrangian libration point acts as a real center of gravity.

In recent years, there has been considerable interest in the libration points because they are thought to be ideal locations for future space colonies. In addition, orbits about the libration points are advantageous for lunar farside communications, and as staging locations for lunar and interplanetary transportation systems.

One of these points, the Earth-Moon L-5 point, is even the namesake for the leading group of space colony enthusiasts, the L-5 Society. Until now, research concerned with space colonization has been mainly theoretical. ISEE-3 should provide the first real flight experience for orbital operations of future space colonies.

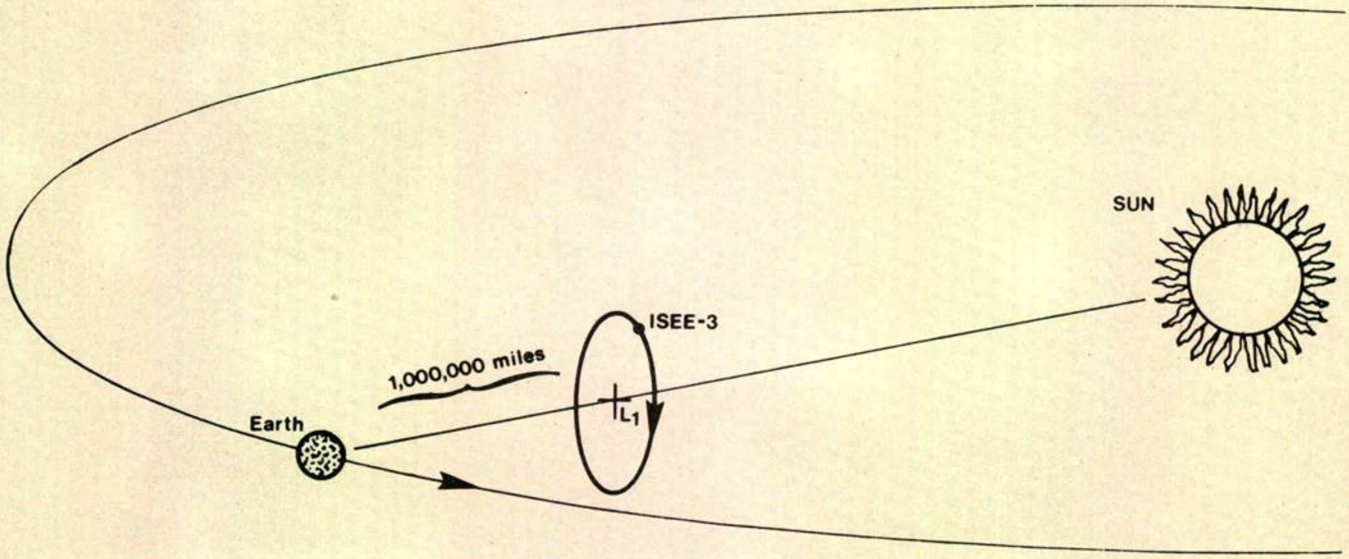
Now that ISEE-3 has been placed into the proper orbit, small station-keeping maneuvers will take place periodically. Approximately eight maneuvers per year will be required of the spacecraft's hydrazine system to maintain the satellite's proper position in space. ISEE-3 will carry enough hydrazine propellant to assure an orbital lifetime of at least ten years.

According to Project Manager Jeremiah J. Madden of the Goddard Space Center, who is managing the ISEE-3 program for NASA, the unusual orbit was chosen for ISEE-3 "because of the relationship between ISEE-3 and the other two ISEE satellites that were launched from Cape Canaveral in October 1977."

"In effect," says Madden, "ISEE-3 will be sort of an early warning satellite for activity on the Sun. It will detect solar wind particles speeding away from the Sun a full hour before the two other Earth-orbiting spacecraft do so. These spacecraft are in highly elliptical orbits ranging from about 174 miles (280 km) to almost 90,000 miles (144,800 km) above Earth. This tells scientists a lot about the Sun and how it changes with time and distance. In fact, this will be the first time such correlated measurements will ever have been accomplished on a regular basis."

ISEE-3, in addition to providing Sun-Earth interaction measurements, will also be useful for research activities on the origin of galactic cosmic rays and recently discovered gamma ray bursts. All three spacecraft will be closely observing phenomena at the period of maximum solar activity for the new 11-year solar cycle which began in June 1976.

HALO *continued on page 58*



The International Sun-Earth Explorer 3 (ISEE-3) satellite is the first satellite to be placed in orbit around a Lagrangian libration point. ISEE-3 circles the mathematical point between the Sun and Earth at which the gravitational forces of the two bodies are in balance. This point is located about one million miles from Earth, while the Sun is 93 million miles away (the diagram is not drawn to scale). From Earth, ISEE-3 appears to be in orbit around the Sun. From its station in space, the satellite will monitor Sun-Earth interactions and provide advance warning of solar flares and magnetic storms.

Scientists Believe Variable Sun Could Affect Earth's Weather

The variation in solar activity over the 11 year sunspot cycle has long been recognized. Now, however, it seems the Sun may be even more variable than had been previously thought, and this solar variability may have a significant effect on Earth's weather.

Some recent investigations have shown a correlation between a "quiet," relatively inactive sun and a general cooling of Earth's climate. One such period of solar inactivity, known as the Maunder minimum (approximately 1645 to 1715), coincided with a period of particularly cold weather in the northern hemisphere, called the "Little Ice Age." But during times of increased solar activity, Earth's weather becomes warmer on the average.

Dr. John A. Eddy of the High Altitude Observatory in Boulder, Colo., who established the reality of the Maunder minimum, has found that as the minimum approached, the rotation rate of sunspots near the Sun's equator increased. His study, assisted by Peter A. Gilman and Dorothy E. Trotter, made use of sunspot records kept by two early observers in the periods 1625-1626 and 1642-1644.

Now another study, by Richard B. Herr of the University of Delaware, has shown that the speedup was even greater than had been thought. His examination of records kept by Thomas Harriot in England during the earlier period (1611-1613) revealed that at that time the solar rotation rate was still slower than the two later periods.

Furthermore, the differential rotation effect also seems to have varied. (Differential rotation refers to the observation that the closer sunspots are to the Sun's equator, the faster they are seen to rotate. At present, the Sun's equator rotates every 25 days, but close to the poles the period is 34 days.)

In particular, the change is greater at lower solar latitudes — as one moves closer to the Sun's equator, the rotation rate becomes even more variable. It is in the Sun's equatorial region that the rotation rate speeds up just before a significant decline in solar activity. During times of high solar activity, on the other hand, the sun seems to rotate more slowly, especially in the equatorial regions. Thus three different phenomena seem correlated: the rotation of the Sun's surface, the level of solar activity as measured by sunspots, and Earth's average temperature. When the Sun's rotation rate slows, sunspots increase and solar activity in general becomes greater, and Earth's climate warms up. But a decrease in solar activity and sunspot incidence is accompanied by a cooling of Earth's weather and preceded by a speedup in the Sun's rotation, beginning years earlier.

Therefore such a speedup in the Sun's rotation would be an indication of the approach of another severe cold spell like the Little Ice Age, accompanied by a decline in solar activity and sunspots.

However, scientists have not yet proven that there are causal relationships between these phenomena. Nevertheless, the correlation seems too high to be purely coincidental. No mechanism has been proposed which could account for such relationships, though it seems logical to suppose that a slowing of the Sun's rotation is connected with a lessening of the internal turbulance which gives rise to sunspots and other solar activity.

The sun's internal turbulence may vary, however; Robert H. Dicke of Princeton University has found that the Sun maintains a very precise cycle of short-term variability, and has also detected a correlation between the short-term sunspot cycle and Earth's climate. The 11 year cycle of sunspot activity can vary from 7.3 to 17.1 years, but Dicke has found that a full sunspot cycle, which includes *two* sunspot maxima and minima (and during which the Sun's magnetic field reverses completely and then returns to its original orientation), maintains an exact period of 22.27 years with an error of only 0.08 years.

Dicke has also found that this period is reflected in temperature variations on Earth as determined by examination of tree rings over the past thousand years. This supports the idea of a link between solar activity and weather on Earth.

Even during the Maunder minimum, when the sunspot cycle seemed to cease, the 22.27 year period was maintained. When the minimum ended, the new cycle was in phase with the pre-minimum one. The Sun, it seems, has some sort of deep internal timer which keeps ticking even during a period of solar inactivity!

If Earth is as sensitive to solar variation as it now seems, and if the sun is even more variable than had been thought, it is more important than ever for us to understand the structure and dynamics of our stellar life source.

HALO *continued from page 57*

The three-spacecraft mission involves 117 scientific investigators from 35 universities and 10 nations. ISEE-3 carries 13 different scientific instruments, three of them by foreign investigators in Holland, Germany, and France.

ISEE-1, managed by Goddard Space Center, and ISEE-2, managed by the European Space Agency (ESA), were the first spacecraft designed to be used together to investigate Earth's immediate space environment.

Now the use of three spacecraft, separated by a controllable, variable distance, allows scientists to study the boundaries between interplanetary space and the space controlled by Earth, and the nature of fluctuations in the boundaries.

ISEE coordination is designed to fit into the International Magnetospheric Study (IMS) program, a worldwide three-year investigation begun in 1976.

As part of this program, ground stations, sounding rockets, balloons, aircraft and satellites (including the ISEE spacecraft) will look at the same pheonomena simultaneously from different points on Earth and in space. Data-exchange offices have been established in Meudon, France and Boulder, Colorado.

Meanwhile, a sophisticated Satellite Situation Center (SSC) at Goddard calculates satellite orbits and publishes them through the Boulder office. The published SSC orbits are designed for correlation with the various IMS systems to indicate when spacecraft data are likely to be especially fruitful.

The coordinated effort is expected to result in a better understanding of how the Sun controls Earth's fluctuating near-space environment and of a variety of solar-terrestrial phenomena, including weather and climate, energy production, and ozone depletion in the atmosphere.

ASTRO-MART
Free Classified Ads For Subscribers
only in
ASTRONOMY

An Ancient Supernova Seen in Vela

The evidence that a very bright supernova (occuring over 6,000 years ago) made a profound impact on the earliest civilizations has been explored in a recent book.

The Once and Future Star, by George Michanowsky, discusses a number of ancient cultural records which he argues can be interpreted as traces of a spectacularly bright star's sudden appearance in the southern sky. Both in ancient Egypt and Sumeria, the origin of civilization is mythically connected with a special star which some records place between two stars in the constellation Vela. At the same point, modern astronomers have recently discovered a pulsar.

Since pulsars are believed to be the remnant of a supernova explosion, this discovery indicates that a particularly brilliant supernova may have occurred in Vela between six and ten thousand years ago. The pulsar in question happens to be the closest known one, less than a third as far as the star whose explosion was observed in 1054 A.D. and which gave rise to the Crab Nebula. At its brightest, the Vela supernova may have exceeded the full moon in luminosity and would have been easily visible by day.

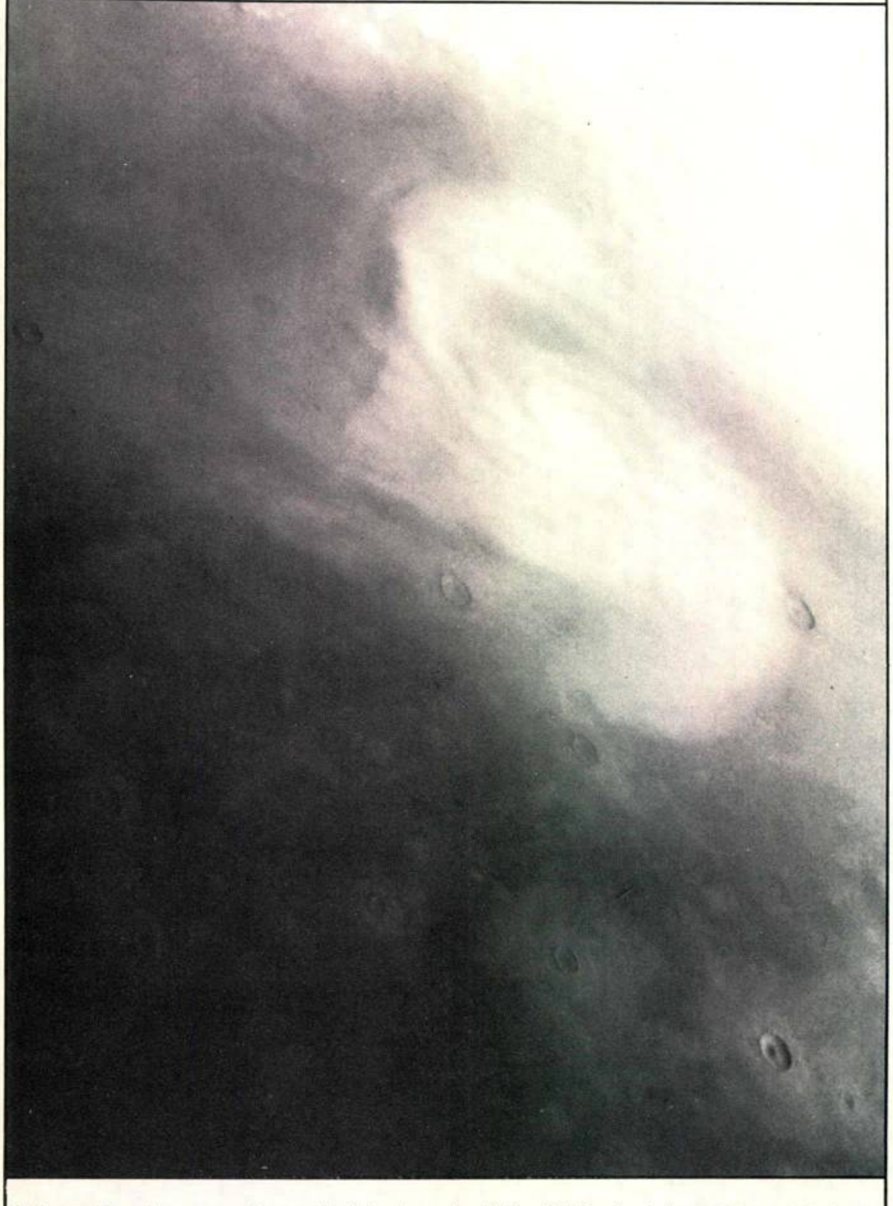
Because of its extreme southern declination, however, the supernova would be visible only very close to the southern horizon as seen from Egypt and Mesopotamia. Nevertheless, such a spectacular sight could have led to a rapid development of science and the arts, and may help to explain the importance of astronomy in the cultures of the ancient world.

A number of Sumerian beliefs link a "gigantic star" in Vela to the god Ea, who was acclaimed as the divine teacher of mankind. Other traces of the event are found in Egyptian culture, according to Michanowsky. The Egyptian goddess Seshat is portrayed with a seven pointed star affixed to her head by a column. An ancient inscription only partially translated reads, "Heaven is pregnant with the Seshat star; Heaven brings forth the Seshat star."

Michanowsky also suggests that the royal emblem of the famed Egyptian Pharaoh Tutankhamun can be interpreted in terms of the Vela supernova. The Pharaoh's title on the emblem is usually translated "Ruler of Southern Egypt," but the author argues that the hieroglyphs can also be translated as "Ruler of the Southern Star." Even the Egyptian ankh symbol, a cross with a looped top, may actually be a representation of the supernova, its brilliant light reflected in a line down below a watery horizon.

If the evidence assembled by Michanowsky does indeed point to an observation of the supernova in Vela, such a sighting would be the most ancient astronomical observation known. The supernova itself would have been the brightest ever seen by mankind in all of recorded history.

A Martian Storm!



This martian storm was observed late last year by Viking Orbiter 1, at about 65° north latitude from an altitude of 18,043 miles (28,640 km). The local season corresponds to late July on Earth. The storm is located near the polar front, a strong thermal boundary which separates cold air over the martian pole from the more temperate air to the south. Since temperatures in this region are well above the condensation temperature of carbon dioxide, water ice is the probable constituent of the clouds. Water vapor concentrations are high during this season in the north polar region. This picture strongly resembles satellite photos of cyclones near the polar front on Earth. The counterclockwise circulation is consistent with the winds expected in a normal low pressure situation in the northern hemisphere. A wind speed at the perimeter of about 20 miles per hour has been calculated. This is quite consistent with winds observed at the surface by Viking Lander 2. The frost-filled crater Korolev (approximately 58 miles in diameter) is located to the northeast (upper right) of the storm at 73° north latitude and 197° west longitude. The white patches at the top of the picture are part of the remnant north polar cap. NASA photograph.

Astrophysicists Meet in Munich

The Ninth Texas Symposium on Relativistic Astrophysics met last December at the Max Planck Institute for Astrophysics in Munich, Germany. The Texas Symposium is so-called because the first such conferences were held in Texas. The Ninth was the first to be held outside the United States.

The Symposium has met at periods over the past fifteen years to consider current problems at the frontiers of astronomy and astrophysics which baffle scientists, such as quasars, the nature of black holes, and cosmological theories. The latest research is reported, new discoveries announced, and an interchange of ideas takes place.

Perhaps the most significant announcement to come out of the Munich meeting was the report by a research team from the University of Massachusetts that direct evidence for the existence of gravity waves had been detected (see Astro-News, February 1979). Long a prediction of Einstein's General Theory of Relativity, gravity waves had never been unambiguously detected before. The University of Massachusetts astronomers obtained observational evidence that gravity waves are being emitted by a peculiar close binary system involving a pulsar and an unknown massive object — perhaps a black hole. But gravity waves have still not been detected directly in the laboratory, although several years ago a researcher reported just such a discovery in a laboratory experiment. But when his experiment was duplicated by other scientists, no gravity waves were found.

Several other significant studies were announced at the symposium in Munich. One involved the discovery of a significant departure from predicted values for the residual cosmic background radiation left over, it is believed, from the explosive beginning of the universe. The observations were described by Dr. Richard A. Muller of the University of California at Berkeley.

Dr. Muller found that the background radiation, occurring at radio wavelengths, does not come equally from all parts of the sky — in technical terms, the radiation is "anisotropic." In particular, an excess is noted in the direction of the constellation Leo. The anisotropy is quite small and difficult to detect, but the most probable interpretation is that our Galaxy, and apparently the entire Local Group of galaxies to which ours belongs, is moving in that direction at a speed of about 400 miles per second.

Such "absolute" motion on the part of the Local Group may represent rotation of a giant supergalaxy composed of many clusters of galaxies, or it may mean that there was a certain "lumpiness" in the cosmic fireball whose explosion gave rise to the universe. Present cosmological theories generally assume the primordial fireball was totally homogeneous, but there is no necessary reason why this should be so. In fact, theorists believe that such complete homogeneity would be somewhat surprising.

In another report, Dr. Halton Arp of the Hale Observatories in California announced evidence indicating that three quasars are associated with the galaxy NGC-1073, a relatively nearby galaxy. He also pointed out that eight other quasars appeared to be aligned across another nearby galaxy, NGC-3384, and that three apparent quasars located near the violently explosive galaxy M-82 seem to have been ejected from it.

Dr. Arp, long opposed to the generally accepted belief that quasars are extremely distant objects, believes this evidence supports his contention that quasars are objects exploded out of active, relatively nearby galaxies.

It was clear at the symposium in Munich that even now, 15 years after their discovery, quasars are still far from being understood. Their energy source, referred to mysteriously as "the machine," is not know, though several possible candidates were discussed.

Among these mechanisms are chain reactions of exploding stars, massive galactic black holes swallowing stars whole, and spinars — spinning accretion disks of matter. The problem of the energy source for quasars would be simplified if it were found that quasars are much closer to us than their redshifts seem to indicate, but no satisfactory explanation for the large redshifts has yet been found.

Clearly, more observations of the strange properties of quasars are needed, including observations from outer space well above Earth's obscuring atmosphere.

Solar Power Satellites: A Threat to Astronomy

Solar Power Satellites (SPS), currently being touted as the answer to the energy crisis, would spell the end of much Earth-based astronomy, according to two scientists. A.T. Young, of the department of physics at Texas A&M University, has calculated that a single such satellite with an area of 50 square kilometers in a synchronous Earth orbit would be the brightest object in the sky aside from the sun and the moon — even if its material were as dark as that of the moon.

According to Young, the total area of sky covered by enough satellites to supply the bulk of our energy needs would be about that of the full moon, and the total light generated would destroy the effectiveness of all present observatories.

Sir Bernard Lovell, professor at Manchester University's National Radio Astronomy Observatory at Jodrell Bank, has pointed out that the stray radiation from SPS microwave beams would make radio observations impossible.

Lovell has estimated that even a single SPS could destroy a radio telescope's sensitivity, though it might be possible to filter out the stray radiation in some cases. But if a number of such satellites were placed in orbit, radio astronomy would become impossible. As Young said, "It would be like trying to do optical astronomy in full sunlight."

Other environmental effects of the SPS must be considered as well, said Young. A number of nocturnal species, including birds who appear to perform a kind of instinctive celestial navigation and other animals dependent on the lunar cycle, might find their life cycles severely disrupted by the bright night sky of an SPS age. Young fears this could lead ultimately to the extinction of some species.

Nor would space telescopes provide an answer to the astronomical problems. Orbiting telescopes would still be subject to interference if a large number of Solar Power Satellites were stationed above Earth.

"The erection of large structures in space," said Young, "will mean the end of astronomy as we know it. Only that work which can now be done during the full moon will be possible — unless we are prepared to move to the far side of the moon."

BRIEFS

NASA has authorized a study of a small lander probe to be sent to Saturn's moon, Titan. The flight is code named SOP2 — Saturn orbiter with two probes — and would be based on the Galileo orbiter with probe that will be launched to Jupiter in 1981. SOP2 will place a survey platform in orbit around Saturn, send a probe blazing into the ringed planet's atmosphere, and send a second probe to land on Titan.

Titan is larger than our own Moon and is the first discovered to have an atmosphere. Consisting of methane, an organic gas, the atmosphere may harbor rudimentary forms of life, according to some scientists' speculations.

Finding the perfect fit is important with space suits, particularly since women have joined the astronaut corps. The Hamilton Standard Corp., Windsor Locks, Connecticut, is developing the Space Shuttle suit life-support system for NASA's Johnson Space Center, Houston, Texas. The system must accommodate extra-small sizes for women. The company is also redesigning parts of the suit to make it easier for both men and women to get in and out of it.

The first High Energy Astronomy Observatory (HEAO-1) ended its 17-month mission in January, 1979. Its supply of attitude control gas had been exhausted, according to NASA.

Strange Asteroid Occultation Seen

On relatively rare occasions, an asteroid may occult a star. As the most recent of these events has again demonstrated, such occultations can produce surprising discoveries as well as accurate estimates of asteroid diameters (determined by the length of time the star is occulted). For example, on June 7, 1978, the asteroid (532) Herculina occulted a star, and observations of the event recorded a second occultation which has been taken to indicate that Herculina possesses a satellite.

Now another occultation has been observed to be double. (And furthermore, the light curve of each occulation indicated the star occulted is a close binary!) On December 11 the asteroid (18) Melpomene occulted the 8.6 magnitude star SAO 114159. But an observing station in Atlanta reported a secondary occultation lasting 5.77 seconds. This may mean that Melpomene has a satellite at least 23 miles (37 km) in diameter.

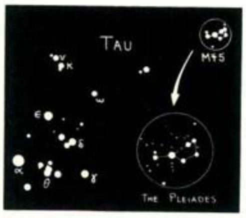
Observations of the primary occultation resulted in a preliminary estimate of 84 miles (135 km) for the diameter of Melpomene itself.

The light curves of both the primary and secondary occultations, however, exhibited a deeper minimum beginning 1.14 seconds after immersion and lasting until 1.14 seconds before emersion. This deeper occultation event apparently means that the star is a binary whose components, roughly equal in brightness, are separated by a tiny 0.011 second of arc — a very close binary indeed.

Previously, such close binary stars have been detected only by spectroscopic analysis. Asteroid occultations may provide a new method for the discovery of multiple star systems, especially in those cases where spectroscopic analysis won't work.

The Messier Album

by John H. Mallas and Evered Kreimer



Are you interested in observing truly exciting deep-sky wonders? Want to know what to look for through the glow of city lights? Seeking new challenges for your binoculars or small telescope?

Sky Publishing now offers you _the_ comprehensive guide to 110 of the heavens' most celebrated sights — the Messier objects. Based on the authors' highly acclaimed *Sky and Telescope* magazine series, this new 248-page volume has it all: beautiful illustrations, expert observations, historical lore, and mountains of useful information.

A valuable observing tool, **The Messier Album** has everything you'll need to appreciate all of these celestial splendors. And you don't have to be an expert observer either — the largest telescope used by Messier was no better than a modern 3½" refractor. Armchair astronomers will also enjoy 31 pages of the finest amateur color photographs ever assembled.

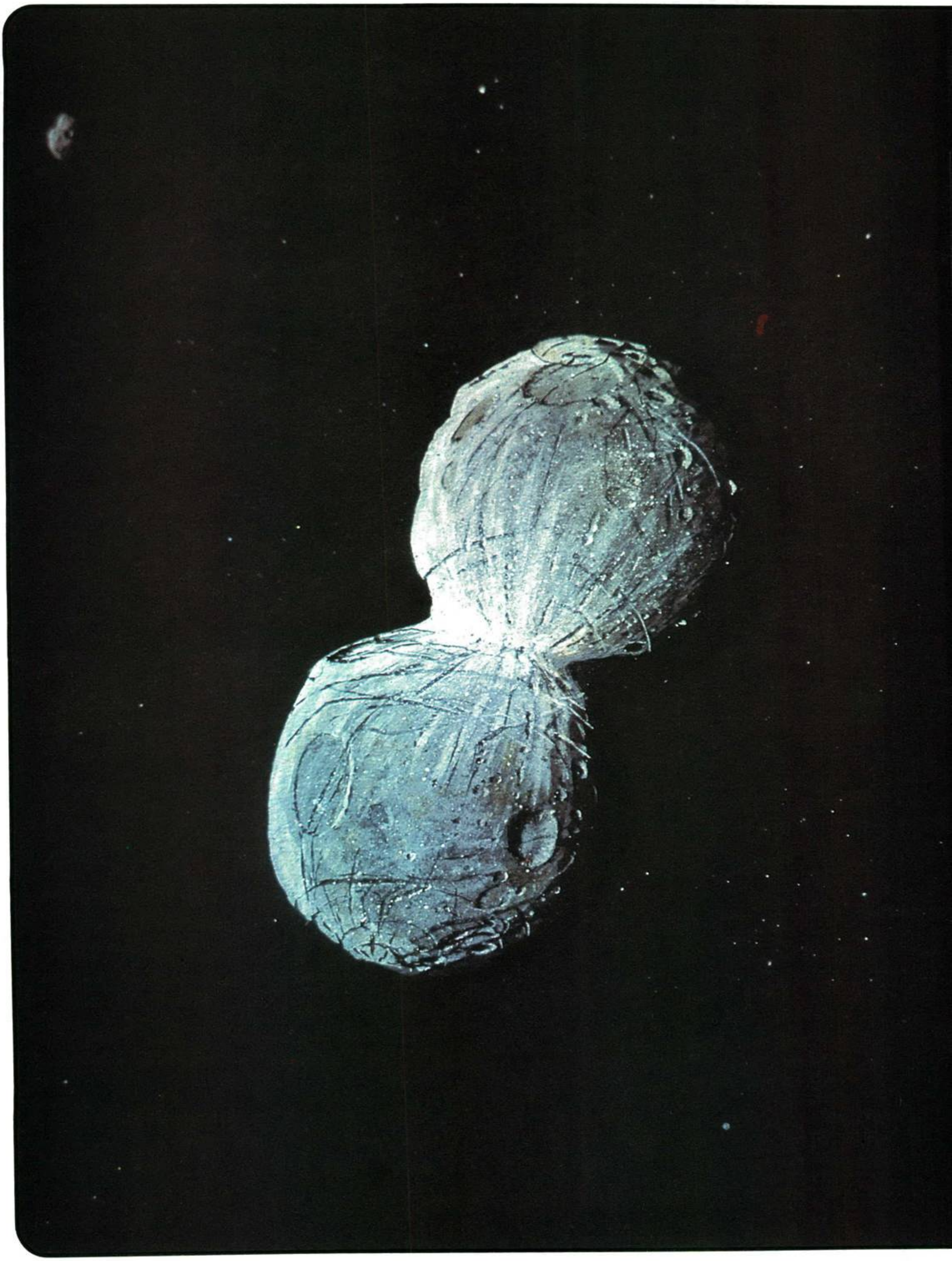
Order your copy today at our special introductory price. We guarantee your satisfaction.

SKY PUBLISHING CORPORATION
49-1 Bay State Rd. • Cambridge, Mass. 02238

THE MESSIER ALBUM by Mallas and Kreimer

Please enclose a check or money order for **$9.50** (payable to Sky Publishing Corp.) with your order. Mass. residents add 5% sales tax.

Name ....
Address ....
....
City ....
State .... Zip Code ....



Hektor — A Strange Asteroid?

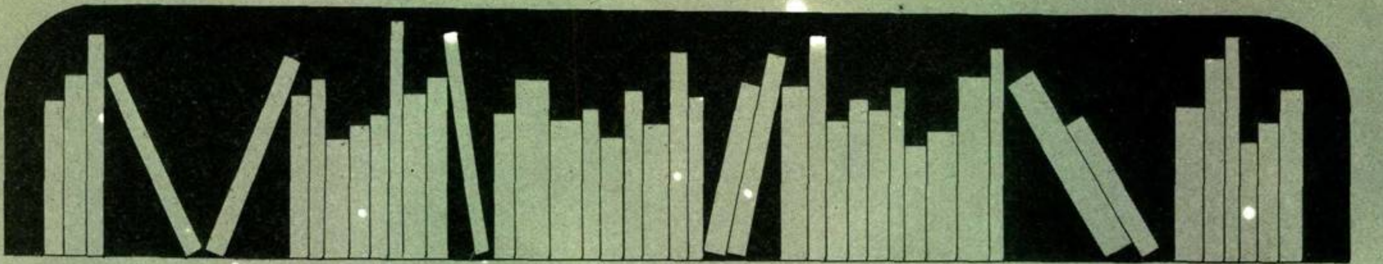
Asteroid 624 Hektor may be one of the strangest objects in the solar system. It isn't chemically abnormal and, although it's an unusually dark asteroid, it isn't unique. It doesn't have an unusual orbit, nor does it have a cloud of sodium around it as Jupiter's moon Io does. So what's different about it? To planetary scientists William K. Hartmann of the Planetary Sciences Institute in Tucson, Ariz. and Dale Cruikshank of the University of Hawaii, Hektor — based on recent measurements — looks like a giant dumbbell about 90 miles across and 180 miles long. They think it was formed by a gentle collision between two asteroids, a collision so gentle that neither asteroid shattered but hard enough that the two stuck together.

What leads these researchers to this remarkable — near incredible — conclusion? Hektor has been studied for over 10 years now. It is known to be one of the Trojan asteroids, asteroids in orbits locked into resonance with the planet Jupiter of which about 10 are known. Hektor's remarkable observational feature is its variation in brightness — a factor of 3.1 to 1 every 6.9 hours which means it must be rotating once every 6.9 hours. But such a large variation implies that Hektor is a cigar-shaped object 3.1 times as long as it is wide! Asteroids are thought to be rocky bodies approximately spherical or only moderately egg-shaped — the products of billions of years of shattering collisions between bodies in the primitive solar system. (Planets are the lucky few that happened to be a bit bigger and so grew faster, while asteroids are the ones that lost out and remained tiny bodies.) It's fairly hard to believe that a process of fragmentation could produce a long, skinny, cigar-shaped asteroid.

Because collisions have probably been an important process in shaping the asteroids, Hartmann and Cruikshank considered the types of collisions that could occur. Asteroids may collide at high speeds (several miles per second) or slow speeds (a few hundred miles per hour), and asteroids may come small (under 80 miles or so) or large (as large as 600 miles). Small asteroids are tougher, but have less gravitation than the bigger ones. When small asteroids hit fast, they shatter and fragments go flying in all directions. Large asteroids hitting slowly probably shatter, but their pieces fall back together again. Small asteroids hitting fairly slowly will bounce apart, and small asteroids hitting *very* slowly may stick without breaking. Trojan-sized asteroids in nearly matching Trojan orbits could undergo a very slow collision — so slow that it could result in two Trojans sticking together. The resulting object would look like two tennis balls stuck together. Seen side-on, the dumbbell could be only twice as bright as the end-on view (because twice the area is seen), but the two scientists expect that the collision area would be brighter than the rest of the asteroid's surface just as the newer craters on the moon have bright halos, shattered and disturbed rock reflects more light than old exposed surfaces.

Observations being made this summer and fall will help confirm or dispose of the theory. If the two original asteroids happen to have been of somewhat different composition, then their reflection spectra should be somewhat different. The researchers hope to obtain good spectra of the asteroid when each end of the dumbbell is pointed toward them; if the spectra are different, it's a plus for their theory. If they're the same, it's a plus for the cigar hypothesis. Whatever the outcome, asteroids are finally coming into the limelight as important solar system bodies worthy of detailed study.

624 Hektor may look something like this: a rather ungainly pair of near-spherical asteroids held together by their mutual gravity. Around the point of impact, material is lighter in color, while large cracks show that the asteroids nearly shattered on collision. For scale, the Martian moon Phobos is shown in the corner. Artwork by William K. Hartmann.



ASTRONOMY REVIEWS

The Night Sky Book
by JAMIE JOBB

127 pages (illus.), paperback, $4.95
Little, Brown and Co. (1977)

Any science, including astronomy, is more interesting to a youngster if it's presented as fun and has easy experiments suggested that are within his or her capabilities. The definition of "fun," of course, depends on the age and interest of the person: A preschool or grade school student requires a light presentation and perhaps a gimmick to hold interest. Older students find their fun in the challenge of a complex problem and the final solution.

The Night Sky Book is presented as an observing guide for the juvenile, but should be used with an adult or experienced sky watcher. A number of terms and descriptions will likely be confusing to a young person who reads this by himself. For example, the term *apparent magnitude* is introduced on page 15 without any previous definition. Also, just prior to the section on magnitude is a comment about the stars "... to judge their size ...", but stars *have* no size as seen from Earth: They vary in their brilliance, but not size. Help is needed here to point out that due to the scattering of light in the atmosphere and on the retina of the eye, you can get a false impression of size that actually doesn't exist. Without clarification, the reader might get a wrong impression.

The general contents are quite good for juvenile study, with the illustrations by Linda Bennett helping make the text clear and easily understandable. Although there is no index, the table of contents is sufficient for locating any discussion in the five sections: "North and Night," "Sphere and Here," "Noon and Moon," "Planets and Orbits," and finally, "Star and Light."

The scattered diagrams of star figures without connecting lines, but with a surrounding list of nearby star figures and some generous hints in the text below, are an unusual approach to constellation identification. To make it more challenging, the stars are presented not as they appear on the meridian, but in various orientations, rising or setting or in some random section of the sky.

Even adults will find it interesting to make the hand sundial described on page 64, while on the facing page is a description of the standard time skyclock. This consists of a dial with a moving pointer that is aligned on a selected star in the area of the pole to give the time. An improvement over previous devices of this type is the viewer's choice of several stars to align the time pointer on, one in the Big Dipper, one in the Little Dipper and one in Cassiopeia.

A few centuries ago, man eliminated the flat earth model for the spheroid; therefore, it's somewhat disturbing to find an illustration and description on page 43 in which a flat surface is your horizon. Carrying on the idea further is the suggestion that you can better visualize a horizon using a phonograph record and a large ball!

This gives the young mind a picture which immediately has to be contradicted by the teacher, since it isn't a true representation. Wouldn't it be better to have kept the sphere and placed a very flat paper cone over it, asking the student to look down the cone to his horizon? This would present a "flat" surface extending to the horizon. It could then be explained that the large size and small curvature of the Earth's surface doesn't let you realize its curvature when you look at the horizon. Now, if you place an object below the horizon on the model and let it extend above the edge of the viewing cone, the student could be shown the dip of the horizon. It may be better for teachers if they use this explanation; or perhaps the book could include it in a future reprinting.

Future reprinting should also catch a few obvious errors: Polaris is faint enough for city viewers at second magnitude and doesn't need to be reduced to third magnitude as mentioned on page 25. Fomalhaut can be seen from the United States and the statement that it can only be seen in the southern hemisphere (page 31) is wrong. Sirius is magnitude -1.46 and not the -1.6 listed on page 77. On page 31 mention is made of the star Algenib in Pegasus, but the label for the star is left off the sky chart on page 30. The description of finding the "O hour angle" in the sky is backwards; one does not draw a line from Algenib through Alpheratz but in the opposite direction, from Alpheratz through Algenib, and extend it southward.

The errors, however, are few for the many facts presented, and the good portions of the book far outnumber the bad ones. This is a "fun" book for the beginner with plenty of interesting experiments, yet simple enough for the juvenile to easily handle. Astronomy scout advisors and junior high school students can find plenty of projects for rainy afternoons while expanding their knowledge of the skies. *Robert E. Cox.*

◆

Skylab Explores the Earth
prepared by JOHNSON SPACE CENTER

517 pages, hardcover, $15.00*
NASA (1977)

For almost nine months during 1973-74, nine men beheld Earth with the "God's eye view", viewing in rapid succession deserts, oceans, forests and cities.

The nine made up the crews of the Skylab space station which was designed to measure man's abilities in space. Included among the solar and medical experiments was an ubiquitous package of six cameras, the Earth resources experiment package (EREP). Each camera, viewing an area 100 miles on side, used color or black and white film sensitive to visible or infrared light.

In addition, a terrain camera was mounted in the airlock, and a porthole in the wardroom could be used for handheld photos.

Skylab Explores the Earth shares a portion of the 2,000 pictures, taken mostly by the third crew. The pictures are striking, showing both minutiae and macrostructures, from smoke plumes to massive eddies in ocean currents. They bring to life geological structures which heretofore were depicted as shadings on paper maps.

Most of the pictures are from the EREP, but many were taken by the crew when, in the wardroom, they saw interesting features go by.

Unfortunately, such a large and costly experiment is unlikely to be repeated. While film provides a permanent record, and is more reliable than the human memory, it lacks the sensitivity of the human eye. Astronauts viewing the pictures after the mission found that tints and hues they saw were not in the film.

In addition, film cannot be used as readily as television images. For large scale use, Skylab's photos must be scanned and digitized into so many bits that can be crunched into useable form (area covered by snow, acres of corn, etc.) by computers. This is one of five coffee table volumes summarizing various aspects of Skylab. It is not a massive technical dissertation, but neither is it light reading. Its best use will probably be for teaching geography, oceanography and geology. In that respect, it should be used as a companion to an earlier NASA book, **Mission to Earth: Landsat Views the World**.

The text, indeed, might be regarded as Skylab's strong point. The photographs are striking, but many, unfortunately, have been blurred ever so slightly by sloppy printing. *David Dooling.*

**Stock number SP-380; available from U.S. Government Printing Office, Washington, D.C. 20402.*

◆

Man and the Stars
by HANBURY BROWN

185 pages, hardcover, $14.95
Oxford University Press (1978)

From the frontiers of the Australian bush at Narrabri in New South Wales has come an elegant, new popular level book by an astronomer who has spent 30 years on the frontiers of astronomical research. Hanbury Brown, a distinguished English radio astronomer, left England in 1962 to direct the Narrabri Observatory where he has pioneered the use of the stellar intensity interferometer. As the head of the astronomy department at the University of Sidney, Brown writes with the authority of a professional astronomer and the style of a British man of letters.

Man and the Stars was written, as Brown states in his preface, "to talk about the relevance of astronomy in the broadest sense". And he admirably succeeds in the five chapters of his book. Each could stand alone; together they make a forceful case for the essential role astronomy has played and now plays in civilized life. The first chapter discusses the astronomical foundations and historical development of the calendar, so necessary an instrument for the ordering of life. "Stars and Time" next traces the development of time measurement methods from early mechanical clocks to today's precise atomic clocks, showing at many points the importance of astronomical considerations. The third chapter follows the numerous interactions between astronomy and man's navigational needs, from early maps through the problems of determining terrestrial longitude, to the difficulties presented by travel beyond Earth.

The interdependencies of physics and astronomy form the focus of Brown's fourth chapter, wherein the development of mechanics and optics from Newton to 1900 is used to set the stage for a presentation of Einstein's theory of relativity, and for a discussion of the nuclear processes involved in white dwarfs, neutron stars and black holes. The last chapter surveys the major transformations in man's view of the cosmos from Dante's time to Hubble's expanding universe. This section especially deals with the influence of astronomy on religion, philosophy and man's other large scale human concerns.

Throughout the book, Brown blends clear, qualitative presentations of major astronomical ideas with interesting historical information. The history is more capably covered than in comparable books, and its presentation is enriched by a generous selection of black and white photographs. A glossary, an index, and a brief selective bibliography add to the usefulness of the book. Brown's British background accounts for the preponderance of allusions in the book to British matters (units of weight, for example), but this should not seriously distract most American readers.

Astronomers, lay or professional, wishing to find a highly literate discussion of the topics treated in this book, or to be reminded of the vital role astronomy has played in civilization, will find this book valuable and enjoyable. (They may also want to use this book to convey to friends a sense of the excitement they feel about astronomy, especially as a cultural pursuit.) Teachers of astronomy could make excellent use of this book by placing it in the hands of nonscience students as an introduction to their study of the oldest of the sciences.

Although the price is rather high, few persons who read it will leave without having their interest in astronomy and its history increased, or without hoping to see further books of similar nature. *Michael Crowe.*

◆

NEW ASTRO-BOOKS

Astronomy and Astrophysics Abstracts
edited by S. BÖHME, et al.

786 pages, hardcover, $47.50
Springer-Verlag (1978)

Volume 20, covering the second half of 1977, lists some 7,800 papers published on astronomy and astrophysics, including related fields. Most of the entries are in English, and many have abstracts describing the research.

The Structure of Planets
by G.H.A. COLE

232 pages, hardcover, $19.50
Wykeham Publications Ltd. (1978)

The subject of planetary geophysics is dealt with for the reader with a physics background at the undergraduate level. The first half of the book covers theoretical basics; the last half examines the planets themselves.

Geared to the Stars
by HENRY C. KING, in collaboration with JOHN R. MILLBURN

442 pages (illus.), hardcover, $50.00
University of Toronto Press (1978)

Mechanical models of the solar system have been with us since the time of the Greeks. This carefully researched and well-illustrated book by the director of the McLaughlin Planetarium in Toronto provides a detailed history of these machines down to the present day. The author's **History of the Telescope** (now out of print) is the definitive work on its subject; this book will likely become the same.

Messages From the Stars
by IAN RIDPATH

241 pages, hardcover, $10.00
Harper and Row (1978)

The popular question of whether life exists elsewhere in the universe, and the story of our searches to find it, is interestingly told in this book by a well-known British science writer.

Stellar Evolution
by A.J. MEADOWS

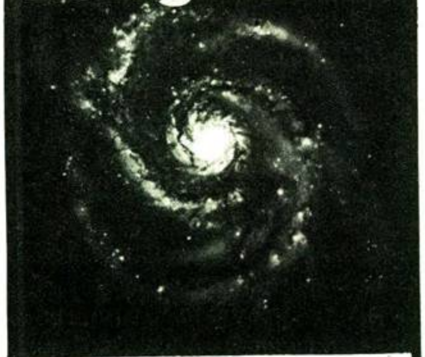
171 pages, paperback, $5.50
Pergamon Press Ltd. (1978)

The informed layman now has an up-to-date survey of the processes of stellar evolution. This is the second edition of a work originally published 11 years ago.

ASTRO-MART

Astro-Mart is a free, reader service department available only to current, paid, noncommercial subscribers; 2 ads are allowed per year. Each ad submitted must not exceed 40 words in length (including name, address, etc.). All ads are subject to editorial review for suitability. Be sure to allow 3-4 months for your ad to appear.

The Next Best Thing To Being There!



FULL-COLOR POSTERS
SLIDES • POSTCARDS
PRINTS • MAPS • CHARTS
A single source for space visuals from
HALE OBSERVATORIES
LICK OBSERVATORY
U.S. NAVAL OBSERVATORY
NASA, AND MORE!
The highest quality, the lowest prices
Posters — $2.00 Slides — 40¢
40% discount on orders over $25.
Write Dept. A for free postcard and our new illustrated catalog.

Hansen Planetarium
15 South State Street
Salt Lake City, Utah 84111

The University of Kansas
Science Camps
Astronomy: June 24-July 7
and July 8-July 21.
Physics: July 8-July 21.

- Study and live on the KU campus
- For student in grades 9-12
- For information write:
- Professor J.P. Davidson
- Science Camps • 143 Malott Hall
- The University of Kansas
- Lawrence, Kansas 66045

STAR INSTRUMENTS
NEBULAR FILTERS

size	visual	photo-visual
.965"	$39.95	$69.95
1.25"	$39.95	$69.95
2" & T-adaptor	$74.95	$104.95

Star-Gazer 6" F4 RFT ppd **$189.95**
W/equatorial mount, clock drive, FOB **$279.95**
all prices postpaid

STAR INSTRUMENTS
17972 Sky Park Circle, Suite K
Irvine, Cal. 92714 (714) 540-8729

We Can Supply All Available Books On Astronomy
BURNHAM'S CELESTIAL HANDBOOK
New Revised Edition
Volume 1, and Volume 2 each ..... $8.50+85¢postage
Volume 3 ..... $8.95+85¢postage
NEW! ASTRONOMICAL DIRECTORY with over 3,000 listings of observatories, planetariums, astronomy clubs & societies $8.00
GOD AND THE ASTRONOMER by R. Jastrow $7.95
ASTRONOMY HANDBOOK FOR AMATEUR ASTRONOMERS, edited by G.D. Roth ..... $14.80 paper, $24.80 cloth
NEW! DR. VEHRENBERG'S ATLAS OF DEEPSKY SPLENDORS. Revised and enlarged edition $37.50
AMATEUR TELESCOPE MAKING
Book 1 $8.00, Book 2 $9.00, Book 3 $10.00
NORTON'S STAR ATLAS $12.50
1979 AMERICAN EPHEMERIS AND NAUTICAL ALMANAC $10.50
Write for NEW enlarged free list of astronomical literature

Herbert A. Luft
P.O. Box 91, Oakland Gardens, New York 11364

Astronomical Instruments Tailored To Your Needs

BY COLE ENERGY SYSTEMS

All the latest CELESTRON and MEADE equipment stocked, with demonstrations by appointment. We offer custom design of instruments and accessories by professionally qualified personnel. Write for FREE brochure.

MICROCOMPUTER HEADQUARTERS

COLE ENERGY SYSTEMS
Dealers for CELESTRON and MEADE
P.O. Box 1214 · Maitland, FL 32751
Phone (305) 831-3809

POTTER SALES & SERVICE
Celestron, *UNITRON*, STAR INSTRUMENTS,
VERNONscope, **UNIVERSITY OPTICS**,
DayStar Filters, DOAA, ASTROPHYSICS,
CROSS OPTICS

Demonstrations by appointment
723 CEDAR, DEPT. AM,
SANDWICH, IL 60548
815-786-8168
master charge
FOR YOUR ASTRONOMICAL NEEDS

FOR SALE — Celestron 8, with lightweight portable pier, piggyback camera mount, and all original standard equipment (oculars, star diagonal, carrying case, etc.). Excellent condition. Price: $750.00 f.o.b. Contact John Z. Wetore, 5305 Bradley Blvd., Bethesda, MD 20014. Phone (301) 654-5305.

FOR SALE — 6" F/12 Crico reflector tube assembly. Optically folded into 50" tube using new Novak Cassegraine spider assembly. New rack & pinion mount, 6x30 finder. Good optics. $80.00 or best offer. Write Ronald G. Samec, 16699 E. Bagley Rd., Middleburg Heights, OH 44130.

FOR SALE — Refractor; 41/8" f/15 Jaegers objective, rack & pinion, prism diag., 6x30 finder, 1-1/2" dia. guide scope, 3 eyepieces, equatorial (no drive or circles): $250.00. Unitron 220B Astrocamera: $65.00. Contact Roger Griggs, 3606 NE 44th St., Vancouver, WA 98661. Phone (206) 695-5671.

FOR SALE — Dynamax 8 with tripod, celestial drive, sunscreen, dewcap, extra eyepieces and filters, pole star alignment accessory. Originally $1,420.00, asking $850.00. 3 years old, used very little. Contact C.G. Justus, 553 Timberland Drive, Atlanta, GA 30342. Phone (404) 894-3890 days, 255-5394 evenings.

FOR SALE — Brandon eyepiece, 1-1/4" diam., 32mm f.l., also University Optics 8.4-21mm zoom ortho. Both 1 year old. Price: $20.00 each. Contact Ron Kilman, 1900 E. 13, Ada, OK 74820. Phone (405) 332-7203.

FOR SALE — Unitron oculars (24.5mm OD): 25mmR; 18mmK (new); 12.5K; 9mmA.S.; 7mmA.S. All of these oculars, including wooden box, $30.00. Also Unitron 40mm Mono ocular (1-1/4" OD): $10.00. Send SASE to J. Light, 3101 S. Ocean Blvd., Highland Beach, FL 33431.

FOR SALE — Unitron components: Star Diagonal (24.5mm OD), $8.00. Flexible Extension Cables for 3" Altazimuth mount (new), $10.00. Sun Projecting Screen (rear White plate new), $12.00. Send SASE to J. Light, 3101 S. Ocean Blvd., Highland Beach, FL 33431.

Advertise it free in Astro-Mart

FOR SALE — Unitron components: 8x30mm view finder minus mounting brackets, $10.00 (damaged brackets included free). Standard model rack & pinion focusing mechanism for 3" Unitron with two draw tubes, $10.00. Send SASE to J. Light, 3101 S. Ocean Blvd., Highland Beach, FL 33431.

FOR SALE — 10" f/6 reflecting telescope. Cave optics and mount. No clock drive, but has setting circles. Parks fiberglass tube. Two eyepieces; one is 8.4 to 21mm zoom. $500.00 or best offer. Contact Pat McGuire, 2053 Christina, Stockton, CA 95204. Phone (209) 463-0691.

FOR SALE — Wide angle Erfle focusing ocular 1-1/4" focal length 68° apparent field, Jaegers #S2670, A1 condition. Price: $55.00. Contact Raymond A. Mitchell, 7 Water St., Assonet, MA 02702. Phone (617) 644-2093.

FOR SALE — ASTRONOMY magazines, July 1976 and October 1976 through July 1978, $1.25 per issue postage included. All in perfect condition, some still in original mailing envelopes and jackets. Contact Andrew S. Anzalone, 58 Atherton Street, Somerville, MA 02143. Phone (617) 776-7579.

FOR SALE — E-K K-40 camera, 48" f.1., f/6.3. 9"x18" format. Weighs 125 lbs. Price: $395.00 plus shipping. Contact John J. Brooks, 3713-B Portofino Way, Santa Barbara, CA 93105. Phone (805) 687-7407.

FOR SALE — University Optics 3.1" refractor. Equatorial, 4 eyepieces, Barlow, 1-1/4" eyepiece adapter. Price: $250.00. Contact Patrick Burns, 2928 N. 59th St., Milwaukee, WI 53210. Phone (414) 871-5907.

FOR SALE — Complete set of astro cards (3 units) in file, $10.00. WANTED —ASTRONOMY back issues: August 1973 through December 1977. Will pay $150.00 plus postage. Contact M.H. Carroll. Phone (509) 375-0981 after 6 p.m. (P.S.T.).

FOR SALE — TI-59 programmable calculator, PC-100 printer, magnetic tapes, programming aids, books. Purchased August 1978. Paid $400.00. Asking $370.00, may negotiate. Will consider selling components separately. You pay shipping. Send SASE for more information to Todd B. Cutick, 85 Darcey Ave., Staten Island, NY 10314.

LAST CHANCE...

...for low, introductory prices on the amazing DayStar 300 Series Nebular Filter.

This is the *all-dielectric* sky-improvement filter designed by *filtration specialists* for superior performance at modest cost. Its peak visual transmission — at 95% — is essentially that of clear glass, while its opacity to the narrow-band emissions of city light pollution approaches the limits of measurement.

Photographically, its three discrete transmission channels — in red, green, and blue light — provide enough spectral information for color photography. Its delicate dielectric coatings are hermetically sealed, its exterior surfaces are A-R coated, and it is warrantied for a full five years in normal use. At current starting prices of $49.95, the 300 Series is a superior value.

But after April 1, prices for the 300 Series will begin at $64.95, because of increased production costs. So to take advantage of current, low, introductory prices, call or write today for complete ordering information:

L. Henzl & Associates
P.O. Box 7000-38A
Rolling Hills, CA 90274
Tel. (213) 541-4331

COULTER'S OPTICAL MART
"THE WORLD'S GREATEST VALUES IN OPTICS FOR ASTRONOMY"

Send for our price list of exciting values in astronomical mirrors, Cassegrain optics, elliptical diagonals, kits and telescopes.

EXAMPLES:

4-1/4" RFT Kits	$ 27.50 ppd USA
6" f/10 astronomical mirrors	29.95 ppd USA
6" F/15 Cassegrain optics	79.50 ppd USA
12-1/2" f/8 astronomical mirrors	187.50 ppd USA
Space age 4-1/4" CT-100 Telescope	169.95 ppd USA

Write or phone for detailed information.

COULTER OPTICAL COMPANY BOX K
IDYLLWILD, CALIF. 92349 Phone 1-714-659-2991

Celestron:
THE BEST FOR LESS

Special Discounts To:
Astro Clubs, Students,
and Educational Institutions.

MEADE INSTRUMENTS
UNIVERSITY OPTICS

PAUL'S
29 KINGSWOOD ROAD
DANBURY, CONN. 06810 U.S.A.

TELESCOPES AND ASTRONOMY FROM EDWIN HIRSCH

Celestron Telescopes C8, special coatings, tripod, wedge —FREE 8" sun/moon filter. Lowest prices on all telescopes, and binoculars.

Quantum Telescopes quality F/15 systems Quantum 4, Quantum 6.

Meade Telescopes 6" and 8" reflectors — research quality photo-visual accessories. 8x50 right-angle straight through finderscope for C8.

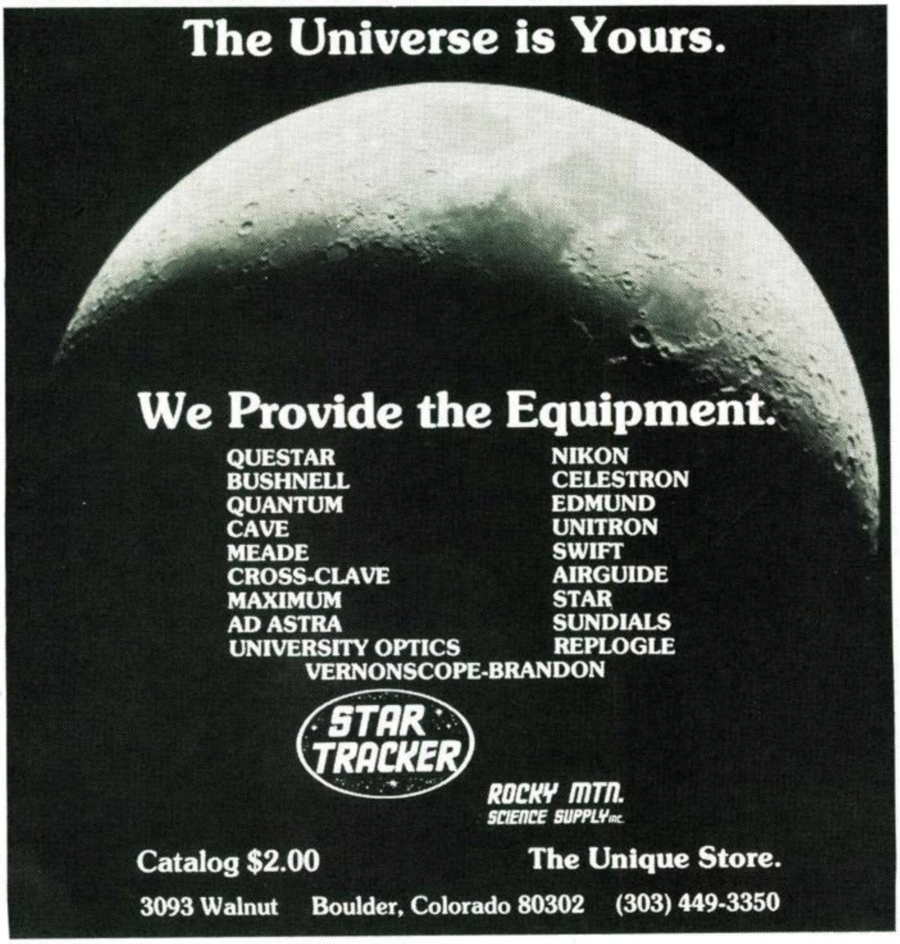
DayStar Filters™ New nebular filters from $49.95, Hydrogen-alpha Solar Filters, 0.75 A HBW from $995.

University Optics quality photo-visual products for telescopes including 8x50 right-angle straight through finder for C8.

Edwin Hirsch, well known to astronomers for his remarkable filtergrams of the Sun taken with the famous DAYSTAR Hydrogen-alpha Solar Filter, shows our Sun and its thousands of faces of ever-changing detail in "Photographing the Sun in H-alpha." (See January, 1978, issue of ASTRONOMY Magazine, page 37.) **Edwin Hirsch** also serves on the staff of Astronomy Island.

Celestron 32 page catalog, instruction manual of your choice: C5/C8, C90, C14 telephoto lenses or Meade catalog $3 ($6 foreign) refunded with purchase.

EDWIN HIRSCH Tomkins Cove, N.Y. 10986 (914) 786-3738



The Universe is Yours.

We Provide the Equipment.

QUESTAR
BUSHNELL
QUANTUM
CAVE
MEADE
CROSS-CLAVE
MAXIMUM
AD ASTRA
UNIVERSITY OPTICS
NIKON
CELESTRON
EDMUND
UNITRON
SWIFT
AIRGUIDE
STAR
SUNDIALS
REPLOGLE
VERNONSCOPE-BRANDON

STAR TRACKER

ROCKY MTN. SCIENCE SUPPLY inc.

Catalog $2.00 **The Unique Store.**

3093 Walnut Boulder, Colorado 80302 (303) 449-3350

FOR SALE — Cave 10" f/7 Model "C" Deluxe reflector, massive mount, slip rings, clock drive, slow-motion declination, 3 eyepieces, accessories. Slightly used — good condition. Cost $1,000.00, sell $675.00. Will deliver —reasonable area. Bill Delavan, 16 Wexford Rd., Dewitt, NY 13214. Phone (315) 446-5685.

FOR SALE — Complete set of ASTRONOMY issues: August 1973 to date. Premium condition. Will sell complete set only — $140.00. Shipment will be made UPS collect. Contact William W. Garstang, P.O. Box B, Belgium, WI 53004. Phone (414) 284-0736.

FOR SALE — Edmund 6" reflector w/heavy duty equatorial, clock drive, setting circles, unique "portable pier" design and long list of extras. Must sell: $275.00. Send SASE to Joseph E. Gortych, 20 Kenwood Rd., Wayne, NJ 07470.

FOR SALE — Play four handed spades on your IBM 1401 or 360/370 with emulator. For details, write L. Gray, P.O. Box 653, San Angelo, TX 76902.

FOR SALE — Celestron 8, wedge, drive corrector, off-axis guiding system, counterweights, Barlow, telextender, T-adaptor, T-ring for Pentax. Price: $500.00 firm. Contact Bob Nesheim, 14 Letts Circle, Monroe, NY 10950. Phone (914) 782-0434.

FOR SALE — 36" wide, super-thin mylar to keep your observatory opening warmly sealed. Described by Peter Sahula in recent magazine article, $0.50 for each foot of length. Write Dr. L. Scarr, 2216 County St., Portsmouth, VA 23704.

FOR SALE — Celestron 10" with fork mount, drive, pedestal. Includes Schmidt camera adapter, custom rack and pinion focuser, 60mm f/8 Unitron guide scope, Astrolab drive corrector. Price: $2,000.00 plus shipping. Contact Tim Sechler, Rt. 2, Box 831, Harrisburg, NC 28075. Phone (704) 455-5570.

FOR SALE — Complete set of ASTRONOMY magazines, August 1973 through December 1978; Sky & Telescope, February 1972 through December 1978; National Geographic, 1970 through 1978. Excellent condition. Best offer. Write P.M. Sendlosky, P.O. Box 724, Johnstown, PA 15907. Phone (814) 266-7798.

FOR SALE — Heavy duty 6" equatorial mount with setting circles, tension knobs, counterweights, $95.00. Kellner 25mm and Ramsden 12.5mm eyepieces, $10.00 each. All very good condition for $110.00. Contact Scott Shafer, 8383 Eastwood, Ida, MI 48140. Phone (313) 269-2811.

FOR SALE — Aerostigmat camera lens, F:5.0, 12-inch focal length, coated. Internal adjustable iris controlled externally by a flex cable, electrically heated, dust cover on both ends, threaded mounting posts. Like new. Price: $125.00. Write Dorothy Sigler, 1936 Water St., Tucson, AZ 85719.

FOR SALE — Hansen Inconel coated solar filter for Celestron 8. New, unused, flat to within eleven wavelengths, holes, slightly cracked at edge. Price: negotiable. Write S.L. Simons, Mathenesserlaan 304, 3021 HW Rotterdam, NETHERLANDS.

FOR SALE — Impossible-to-find 12.5" f 5.2 Cave mirror, excellent performer. Two 2" focusers, unused. 65" predrilled 15" I.D. Meade tube. Assemble your own large aperture instrument. All for $250.00 plus shipping. Contact John Simpson, 366 Gallup Rd., Princeton, NJ 08540. Phone (609) 924-8497.

FOR SALE — Selsi 80mm refractor, 910 focus, equatorial mount, setting circles, slow motion controls, wooden tripod, eyepieces, case, more. Price: $250.00. Contact Peter Sofio, 51-36 30th Ave., Woodside, NY 11377. Phone (212) 626-1791.

FOR SALE OR TRADE — Five inch F/5 RFT refractor with tripod and equatorial mount (no drive). Takes 2-3/8, 2 and 1-1/4 eyepieces with star diagonal. Price: $250.00. Contact James Scala, 44 Los Arabis Circle, Lafayette, CA 94549. Phone (415) 283-2753.

TRADE — Two copies of the special bicentennial July 1976 edition of ASTRONOMY in mint condition. Will trade them along with a sum of money for August, October & November editions of 1976. Write Michel Du Sablon, 551 Groulx, Ste-Agathe-Des-Monts, Quebec, CANADA J8C 1N7.

TRADE — Medical binocular microscope, mechanical stage, Abbe condensor, three sets of oculars (50 thru 970 *magnifications) in wooden case* with all accessories, for Celestron C5, Dynamax 8 or equivalent. Write Larry Kent, P.O. Box 2, Dixie, GA 31643.

TRADE — Correspondence via astronomy — related picture postcards (e.g., telescopes, planetaria, stellar objects) franked with similar postage stamps (e.g., Copernicus, Pioneer Jupiter, Mariner Venus/Mercury, Skylab, Apollo-Soyuz). Write George Thompson, 15316 Yukon Ave., Lawndale, CA 90260.

WANTED — 2x-3x telenegative adaptor, 1-1/4" O.D., such as Meade #124. Contact Andy Buschmann, P.O. Box 189, Desha, AR 72527.

WANTED — Criterion field tripod, will pay $100.00. Contact D.B. Coburn, 1311 Sierra Dr., Arroyo Grande, CA 93420.

WANTED — Astrophoto equipment for Celestron 8 inch. Need any or all of following: off axis guide w/ illum. reticle, telextender, telecompressor, piggyback mount, T-ring, counterweights. Contact Robert Cowart, 3578 Clubland Dr., Marietta, GA 30067. Phone (404) 971-8753.

WANTED — Tickets to the Treasures of Tutankhamun in New York. Contact Stephen DeMarco, 209 Hansell Rd., Lansdowne, PA 19050. Phone (215) 284-5495.

WANTED — ASTRONOMY magazines. Will purchase any singles, sets, part years, not available as back issues. Top price offered. Write now to R.B. Dixon, 4657 Irmin St., Burnaby, British Columbia, CANADA V5J 1Y1.

WANTED — Serious deep sky enthusiasts to join the National Deep Sky Observers Society. Photo library, research projects, more. Club journal (approximately 14 pages). Membership available to anyone, worldwide. Write Alan Goldstein, Coordinator, NDSOS, 3430 Bryan Way, Louisville, KY 40220.

WANTED — Almost any book by H. Allen Smith. Will pay any reasonable price and postage. Send title and price to L. Gray, P.O. Box 653, San Angelo, TX 76902.

WANTED — Commercial or homemade models (built or unassembled): satellites, spacecraft, rockets, astronauts, experimental aircraft, space related. Needn't be in best condition. Write Dennis Kocher, 2307 Tyrolean Way, Sacramento, CA 95821.

WANTED — Books or other publications concerning naked eye astronomy. Also correspondence with clubs or persons interested in naked eye astronomy and star lore. Write R.J. Morris, 219 Chambers St., Rossville, GA 30741.

WANTED — Back issues of ASTRONOMY: September, October, November, December 1973; January, February 1974. Will pay $15.00 each in good condition. Write John Nyberg, 17410 Darden Rd., South Bend, IN 46635. Phone (219) 272-4262 after 6 p.m.

WANTED — Slides of Uranus and Neptune. No artists conceptions! If you have information please call or write Phillip Pishitelli, 370 Naiche Ct., Columbus, OH 43213. Phone (614) 864-3332.

WANTED — Telescope. Set up for deep-sky astrophotography preferable. Large aperture desired. Celestron, Cave, Star-Liner, Criterion, etc. Contact Steven Rothstein, 27 Kenwick Dr., Rochester, NY 14623. Phone (716)334-8271 or 458-2550, Ext. 221.

WANTED — "Third Edition of Variable Stars General Catalogue" by B.V. Kukarin et. al. (1968). Also First and Second Supplements. Write stating condition and price to Chris E. Spratt, 1431 St. Patrick St., Victoria, British Columbia, CANADA V8S 4Y5.

WANTED — Copies of "Astronomy for Amateurs" by James Sayre Pickering, Fawcett book 489 - copyright 1961. Write Al P. Watry, 727 N. Milwaukee St., Port Washington, WI 53074.

Advertise it free in Astro-Mart

INFORMATION WANTED — Anyone interested in forming an astronomy club in Rockland, New York. Call Frank at (914) 634-0097.

INFORMATION WANTED — Astronomical club or observatory in Portland area. Write J. Benoist, 911 S.E. 60th Ave. #204, Portland, OR 97215.

INFORMATION WANTED — Astronomy clubs and activities in the Minneapolis-St. Paul area. Write or call Ron Cole, 813 Smetana Rd. #8, Hopkins, MN 55343. Phone (612) 933-2247.

INFORMATION WANTED — Correspond-ence with persons between 13 and 20 interested in astronomy. Write Ed Higgins, 12232 Moss Point, Strongsville, OH 44136.

ASTRONOMICAL DATA SERVICE

Offers these computer assisted publications to night-sky enthusiasts around the world:

SKYWATCHER'S ALMANAC
LOCAL PLANET VISIBILITY REPORT
SUNLIGHT SUMMARY
COMPARATIVE EPHEMERIS

For publications brochure, send 30¢ (refunded with order, stamps O.K.) to:

Roger L. Mansfield, Manager
Astronomical Data Service, Dept. A
3922 Leisure Lane
Colorado Springs, CO 80917

PALM BEACH — CELESTRON PERSONAL DEMONSTRATIONS

Graduate engineer with over 20 years experience in optics and astronomy to help you select the right telescope and accessories for your requirements.

DISCOUNT PRICES

Complete Celestron Line in Stock
Celestron 11x80mm Binoculars—$179
Send Check - VISA/Mastercharge-Money Order
Free Shipping - Satisfaction or Refund
Call or Write for Free Brochure - Discount Price List or Custom Package Quote

ATLANTIC OPTICS (305) 793-9465
1302 NIANTIC TERRACE, DEPT. AM
WEST PALM BEACH, FLA. 33411

YOU CANNOT AFFORD TO BUY A CELESTRON

Without Calling Us For The Most Competitive Prices To Be Found Anywhere

SPECIAL THIS MONTH: SAVE$$

CELESTRON 8
Special coatings, wedge, and tripod

CELESTRON 90
Astro telescope with Celestron wedge and solar filter.

CELESTRON 90
C90 on Meade equatorial mount, 18mm ocular, Barlow lens, diagonal. $375

μTRACT.M.
Available Soon — A New Standard in Drive Correctors

Free shipping in Continental U.S.A. California residents please add sales tax.

96 pages of catalogs and manuals-$2.refundable with first order. Free price list on request.

Demonstrations by appointment, or call to discuss your specific needs.

OPTRON SYSTEMS

EUGENE L. CISNEROS
OPTRON SYSTEMS
704 Charcot San Jose, CA 95131
Phone: (408) 263-5422 Days
923-6800 Evenings

TEXAS NAUTICAL REPAIR CO.

We should be the last place you call! Tell us what price you've been quoted by any other dealer on a Celestron, Meade, Unitron, or Edmund telescope, and we will go light-years out of our way to beat or match it. Even if we can't, you will have found out yourself that we are the dealer that really cares! We won't try to sell you something that you don't need or want, and we don't deal in "Gimmicks". We sell service, at honest prices!

We also carry accessories by Meade, Gieseler, Edmund, Clave', and others. Call us for your astronomical needs.

3209 Milam, Houston, Texas 77006
(713) 529-3551

"Priceless . . ."

'Your Astronomy courses are excellent. Never have I undertaken any educational course where the school was more interested in actually wanting its students to LEARN what was taught, rather than issue a passing grade. What I have learned is priceless. Many thanks."

Jack D. Ellis, Oklahoma City, Oklahoma

Coast Navigation School specializes in individual instruction. Call or write today for our free course catalog describing our streamlined home study courses designed especially for amateur astronomers.

CELESTRON Schmidt-Cassegrain and UNITRON refractor telescopes available. Special prices on course/telescope combinations.

Coast Navigation School of Astronomy
Dept. 5394 22 North Milpas
Santa Barbara, CA 93102/(805) 963-7837

I'm interested! Please send me your free school catalog.

Name
Address
City
State, Zip

GOD
AND THE
ASTRONOMERS

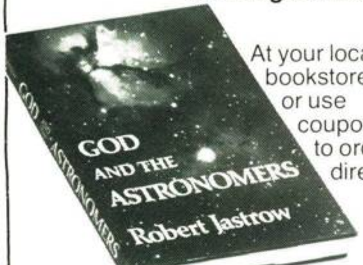
BY
ROBERT
JASTROW

"Professor Jastrow distinguishes fact from speculation in the current scientific cosmology....He has such a sure grasp of his subject that he dares to do things a lesser authority would never do." – GERALD JONAS, *New York Times Book Review*

"There are very few scientists capable of writing so fearlessly and honestly as Dr. Jastrow does in GOD AND THE ASTRONOMERS."
– SIR BERNARD LOVELL

"The giants of astronomy are introduced as real, human people: Einstein, de Sitter, Hubble, and Humason."
– Peninsula Herald

"Color plates of exceptional beauty."
– Washington Star



At your local bookstore, or use coupon to order direct

A3
W.W. NORTON & COMPANY, INC.
500 Fifth Avenue, New York, N.Y. 10036

Please send me ______ copy(ies) of GOD AND THE ASTRONOMERS by Robert Jastrow at $7.95 each (publisher pays postage). If not completely satisfied I may return the book(s) within 10 days for full refund. I enclose $ ______ check or money order.

Name ______
Address ______
City ______
State & Zip ______

ECLIPSE CHASERS TO INDIA
Feb. 16, 1980–Total Solar Eclipse
Special Package Tour Includes:
All transportation & accommodations. 13 days. $1288 from New York. Connections available from other points in North America.
Contact: I.T.S.; 2031 Broadway,
Ste. 3; Boulder, Colo. 80302
(303) 443-7584

STELLAR AND GALACTIC EVOLUTION FROM POINT SOURCES

A paper anticipating Venus probe questions.

H.D. Jones
P.O. Box 7427
North Kansas City, Mo. 64116

$3.00 postpaid

LUNAR EARTHRISE FULL EARTH
EARTH with MOON

The most breath-taking scenes in space (NASA) are now available as titled, 22"x34" **full-color art prints**. Highest quality lithographs on heavy Kromekote, finished with MarKote. Ideal for permanent framing & display in office, home & school. Beautiful gift. Guaranteed. $14.95 each plus $3.05 air pstg.

ORDER NOW TOLL-FREE!!
ex. Calif. 1-800-824-7888, Oper. #462
in Calif. 1-800-852-7777, Oper. #462
WOODSTOCK PRODUCTS, PO Box 4087, Dept. A6 BEVERLY HILLS, CA 90213 (213-650-6602)

INFORMATION WANTED — Possible propulsion systems for futuristic spacecraft. Please include diagrams, if possible. Write Daryl Clarke, 300 Anspach St., St. John's, Newfoundland, CANADA A1E 4M4.

INFORMATION WANTED — Correspond-ence with person over 25 years old living south of the equator to discuss circumpolar objects. English and French, willing to learn Spanish or other language. Write Tony Mallama, 5C Eastway Rd., Greenbelt, MD 20770.

INFORMATION WANTED — Persons of all ages interested in helping to build permanent observatory on semi-isolated land (bluff 122 ft. above Meramec River, 35 miles west of St. Louis, 2-1/2 miles from I-44), full time security. Contact B. O'Dell, Rt. 4, Indian Hills, MO 63069.

INFORMATION WANTED — Someone in the Winterset, Iowa area who would like to get together and do some serious observing. Call Brian Patten. Phone (515) 462-2201 after 4 p.m.

INFORMATION WANTED — Persons interested in Egyptians, Mayans, Aztecs, Druids, etc. Mainly their astronomy/as-trology, magic and religion. Also people interested in Atlantis, Lemuria, Easter Island, Stonehenge, etc. Contact Gary Stevens, 1009 North St., Suffield, CT 06078.

INFORMATION WANTED — New writers, authors unpublished manuscripts? Interested in manuscripts on astronomy, UFOs, science, photography, and general subjects. Manuscripts invited. We market published books. State interest. Free information. Contact New Age World Service, c/o Ramsay P. Vandertuin, P.O. Box 3086, Huntington Park, CA 90255.

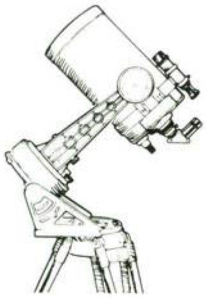
INFORMATION WANTED — Correspond-ence with persons (preferably 18 and older) about their views on astronomy, astrophysics and the unmanned space exploration program. Write Lisa Wainio, 1119 Broadway, Apt. E., Santa Monica, CA 90401.

FREE — Illustrated catalog of astronomy, science fiction, fantasy, stationery, prints, drawings and paintings, and lots more. Write Linda Leach, 19132 Appleton, Apt. C218, Detroit, MI 48219.

REFLECTORS — REFRACTORS — CATADIOPTRICS ???

Which system is best for you? With all the different types of telescopes being sold today it's hard not to get confused. Each manufacturer claims theirs is the best, making it difficult to make a logical choice. At Cygnus we sell all types as we know each has special points in its favor for particular applications. We have a bulletin available that we think will help you cut through the advertising haze. A copy is sent free with every catalog package.

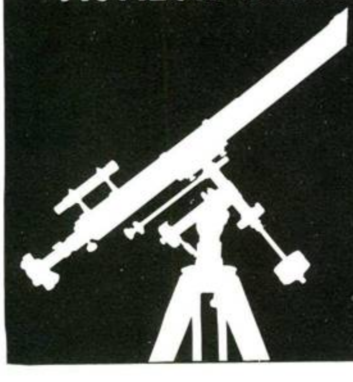
We give fast service, expert advice, and our prices are the lowest in the industry. Dealer for: CELESTRON, UNITRON, MEADE, STAR INSTRUMENTS, BUSHNELL, BAUSCH & LOMB, SWIFT, TASCO, MAYFLOWER. and SKY PUBLISHING. FREE PRICE LIST — Complete Catalog package $2.00; refunded with any order.



CYGNUS INSTRUMENTS
Box 90596, Dept. AM
Nashville, Tenn. 37209
(615) 297-6879

We honor Master Charge and BankAmericard.
Free UPS shipping on most items in continental U. S. A.
CYGNUS — Dealers for quality Telescopes and Binoculars.

Horizon Telescope Discounters Co.



Get CAVE, CELESTON, MEADE, NIKON, OPTICAL TECHNIQUES, TASCO, and UNITRON quality telescopes; telephotos; guidescopes; spotting scopes; astrocameras; binoculars, and accessories, at AFFORDABLE PRICES! We cut the sales pitch, cut all costs to a bare minimum, and pass on BIG SAVINGS to you! Some Optical Tech. "Quantums" stock and on order for prompt delivery but are not allowed to be "discounted". New "Used Telescope Listing Service, also! Call or write for price lists today!"

Horizon Telescope Discounters Co.

Box 12033
Norfolk, VA 23502
(804) 486-6070

FREE — Star image displacements during solar eclipse not Einstein proof! Newtonian gravity, solar atmospheric refraction, lunar gravitational bending over 1/400 travel time & 400 times closer passing distance, produce considerable angularity change! Write W.T. Thomas Jr., 408 Vermont, Daytona Beach, FL 32018.

ANNOUNCEMENT — Sometimes available for illustrated lecture on social & cultural impact of UFO Reports & Theories. This is a public service, no fee beyond expenses. Contact Professor Robert Creegan, Philosophy Department, State University of New York at Albany, 1400 Washington Ave., Albany, NY 12222.

ANNOUNCEMENT — Looking for people to play simulated science-fiction and fantasy war games. Face-to-face in Central Arkansas & play-by-mail for anyone in the U.S. Send 50¢ for information to The Trake Gaming Society, c/o Vincent Fredrick, Rt. 2, Box 332-J, Benton, AR 72015.

ANNOUNCEMENT — The San Francisco Amateur Astronomers meet on the 3rd Wednesday of each month. Place: The Randall Museum, 199 Museum Way, San Francisco, Calif. Time: 8 p.m. Programs of interest to beginning and advanced amateurs. For information call Paul R. Gregory. Phone (415) 664-0184.

ANNOUNCEMENT — Attention astrophotographers: mark & save March 10, 1979 for Astrophoto III. Astrophoto III held at Moorpark College, Northwest of Los Angeles. For registration, papers submission and proceedings purchase information send SASE to Hal Jandorf, 6404 N. Amherst, Moorpark, CA 93021.

ANNOUNCEMENT — January 1967, astronauts Virgil I. Grissom, Edward H. White, and Roger B. Chaffee died in the Apollo I accident. Please write to the President suggesting that the next three Shuttles be named after them, carrying on their memory.

ANNOUNCEMENT — Amateurs in northern New Jersey are invited to join the Sheep Hill Astronomical Association, which recently completed construction of an observatory equipped with a 16" telescope. Write P.O. Box 122, Boonton, NJ 07005 or call Rick Kurczewski (201) 290-9950.

Photograph by Nile Root.
Unitron 4" telescope on an Equatorial mount.
Taken with a Nikon F camera.

Travel through Unitron to the far reaches of space.

When you do, you'll enter an exciting new world of awesome beauty. As you scan the heavens, your Unitron will reveal the panorama with breathtaking sharpness and clarity.

Whatever Unitron model you choose, you can be sure you've selected the finest—in value and quality. A precision instrument with superb optics that will give you pleasure for years and years.

Come travel through space with us. Write for our illustrated brochure today, and select the instrument you'll be proud to own. Unitron Instruments, Inc., 101 Crossways Park West, Woodbury, N.Y. 11797.

UNITRON

The value line.

Unitron Instruments, Inc.
Sub. of Ehrenreich Photo-Optical Industries, Inc.

Save Up To 25%

PI-IN-THE-SKY
DISCOUNT DISTRIBUTORS, INC.
P.O. Box 1350A Montclair, N.J. 07042

We also carry the best in books, casters, and other related products at **low low prices.**

DISTRIBUTORS FOR:
EDMUND
MEADE
DAYSTAR
SOURCE
DRACO
& OTHERS

Send $1.50 for our catalog which is filled with money $aving values.

INSTANT ASTROPHOTOGRAPHY

Now you can take high quality photos of celestial objects through your telescope without expensive camera or darkroom equipment. Our camera uses Polaroid® black & white and color film packs. For telescopes that accept standard 1-1/4 inch diameter eyepieces.

$69.50 ppd in USA.
Innovative Optical Materiel
P.O. Box 243, Dept. AM, Crest Park, California 92326

EINSTEIN POSTER

An unusual sepia-toned lithograph of this **actual photo.** Einstein riding his bicycle! Fine for framing at 16 1/2" x 22". Send $4.95 plus $1.00 postage and handling to:

The Scientist's Gallery
Box 2004, Dept. 1,
Boulder CO 80306

B.E. Meyers & Co.
Precision Optical Systems & Components
Industrial Machine Tools

SALE!
220 V 50 Cycle C-8
For Export-Prices Far
Lower Than U.S.! March Only!

DON'T BE CHICKEN! CALL US FOR THE BEST DEAL!

We'll beat any Celestron dealer's price plus include a free heavy duty latitude adjuster, and deliver immediately from stock. 18 years of optical sales and manufacturing experience.

Henrietta says...

C-8/C-14 Tangent Coupler and Mounting Bar. Coupler rotates 360° + 15° Tilt, all stations lockable. $125

Rubber Eye Cups, $3.95.

Kang-A-Pouch, $5.00.
C8 Rubber Dew Caps, $19.95.
C8 Latitude Adjuster, $25.00.
C14 Latitude Adjuster, $49.95.

C14 Anti-swing Weight, $27.00.
C90 Dew Caps, $10.00.
Astroscan Finders, $17.95.

SOLAR FILTER MATERIAL
$5.00
per sq. yard

Jet 1024 Lathe
Reg. $2045.00
Sale $1850.00

Jet 16 Milling-drilling machine
Reg. $1445.00
Sale $1325.00

Coming In April complete Gyroscope System for stabilizing hand-held optics.

Stocking dealer for Celestron, Meade, Edmund, Unitron, Day-Star, Astro-Physics, VERNONscope, DOAA, Gieseler, University Optics, Bushnell, Bausch & Lomb Microscopes, Sony TV, Dover, Sky Publishing, Gall Publications, Jet lathes, mills, more. Free shipping on most items in the U.S.A. Plus we maintain a complete optical and machine repair facility. We honor Master Charge and VISA.

Many fine like new used telescopes in stock.

Satisfaction guaranteed or money refunded.

Telephone: 206-392-2237

B. E. Meyers & Co. 2717 200th Ave. S.E., Issaquah, Wash. 98027

NEW THE CELESTRON RFA (RICHEST FIELD ADAPTOR)

Attention Celestron owners! Are you interested in quadrupling the brightness of faint deep sky objects and in doubling the actual field-of-view through your C5, C8, or C14? Well, now you can with the Celestron RFA (Richest Field Adaptor). Your Celestron will perform on faint objects like a fast F/5 (for C5 or C8) or F/5.5 (for C14) Newtonian telescope.

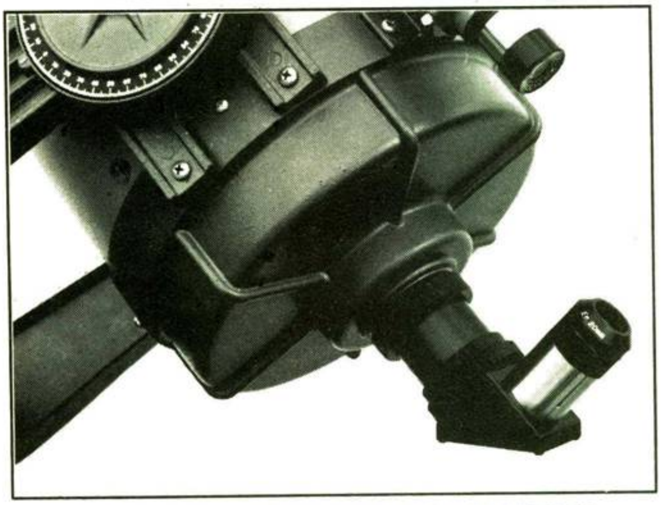
The Celestron RFA is a visual model of our widely used photographic tele-compressor. It differs significantly from other units now on the market in that it allows right angle viewing, via a specially developed star diagonal, which is a great convenience when observing any object overhead. The RFA is compatible with all Celestron telescopes (except the C90).

The RFA is made up of several components whose specifications and dimensions are critical (see photo below). A special custom T-adaptor is used, to mount the device on the back of a Celestron, a Tele-Compressor lens is threaded on the T-adaptor, then a custom threaded ring is attached to the Tele-Compressor lens, then a custom star diagonal is attached to the custom ring, and finally the 20mm Erfle ocular is inserted in the diagonal. The RFA Diagonal may be rotated to any convenient viewing position merely by loosening the slip ring, moving it to the desired position, and retightening the ring.

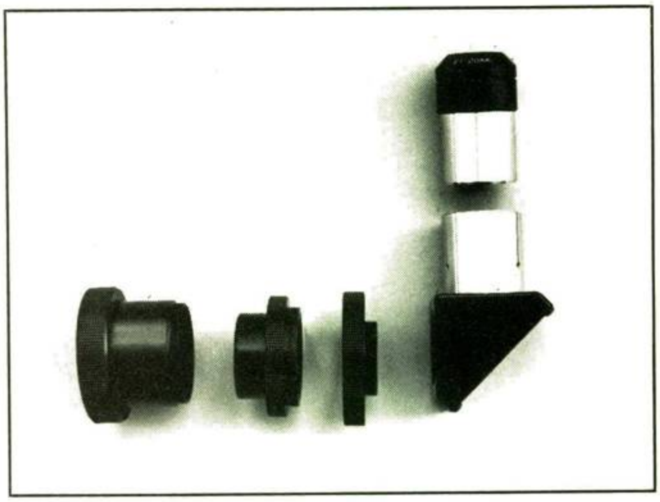
Optimum performance on most objects will come from using the new wide-field 20mm Erfle ocular supplied with the RFA. The RFA is also fully compatible with the Celestron LPR Filter. The LPR Filter and RFA make a spectacular combination for deep sky observing under less than ideal conditions.

You may use any 1¼" O.D. ocular in the RFA, however, many long focal length oculars supplied by other manufacturers may exhibit some vignetting. The RFA will double the field-of-view of any Celestron 1¼" O.D. ocular *without* any vignetting. You may notice some aberration near the edge of the field when using the RFA. This is normal and much less objectionable than the coma inherent in every short focus reflecting telescope.

Price of RFA $^{\$}150^{00}$



RFA ATTACHED TO THE BACK OF A CELESTRON



COMPONENT PARTS OF THE RFA

20mm Erfle Ocular — One of the finest wide-field oculars obtainable.

This new item offered by Celestron is the same unit supplied with our RFA. The wide apparent field is approximately 75°. Works extremely well on all Celestron telescopes and also on other type telescopes with F/11 or lower ratios. It is manufactured to the highest optical specifications. The ocular is threaded to accept filters and can be used with our Tele-Extender (most other units on the market will not work with our Tele-Extender). This ocular is 1¼" O.D. but can be used with .96" diagonals by using our 1¼" to .96" reducer bushing.

PRICE — $60.00 FOR THIS 20mm ERFLE OCULAR

Celestron International 2835 Columbia St., Box 3578B, Torrance, CA 90503. Telephone (213) 328-9560

STAR DOME

March

by
Dewey Schwartzenburg
and
James Mullaney

Long in pagan peril, once the world believed / That Cypria the lovely did send mad love / Down from the third epicycle where she revolves.

These lines from Dante's **Divine Comedy**, written shortly after 1300 A.D., reflect an almost modern skepticism about the power of the planets over human life. Cypria (Venus), once regarded as a goddess of love, is for him only a planet revolving about us in Ptolemy's third epicycle.

The planets, literally the "wanderers" of the skies, commanded great attention from ancient peoples. Although starlike in appearance, they are like the Sun and Moon in their wandering about the sky among the fixed stars. Their peculiar motion, as well as their brightness, definitely marked out the planets as objects different from the stars, but obviously not comparable to the Sun and Moon.

Of the five planets easily visible to the naked eye — Mercury, Venus, Mars, Jupiter and Saturn — two, Mercury and Venus, never stray far from the Sun and are seen only in morning and evening. In fact, Venus at first was thought to be two separate bodies, and so was known by two different names. As a morning star it was called *Hesperus*, but *Phosphoros* was its name as the evening star. It was finally noticed that Hesperus and Phosphorus were never visible during the same period of time, and that before each appeared close to the Sun, there was a time during which neither was visible. This, plus their similar appearance in the sky, convinced early astronomers that the two were in fact a single body, swinging from one side of the Sun to the other.

On the other hand, the three outer planets, Mars, Jupiter, and Saturn, seemed free to wander about independent of the Sun. They were, however, confined (along with Mercury and Venus) to a band in the sky defined by the path of the Sun. This band became known as the *Zodiac*, derived from the same Greek word as zoo, because many of the constellations located along it were early recognized as animals: a lion (Leo), a bull (Taurus), a ram (Aries) and so forth.

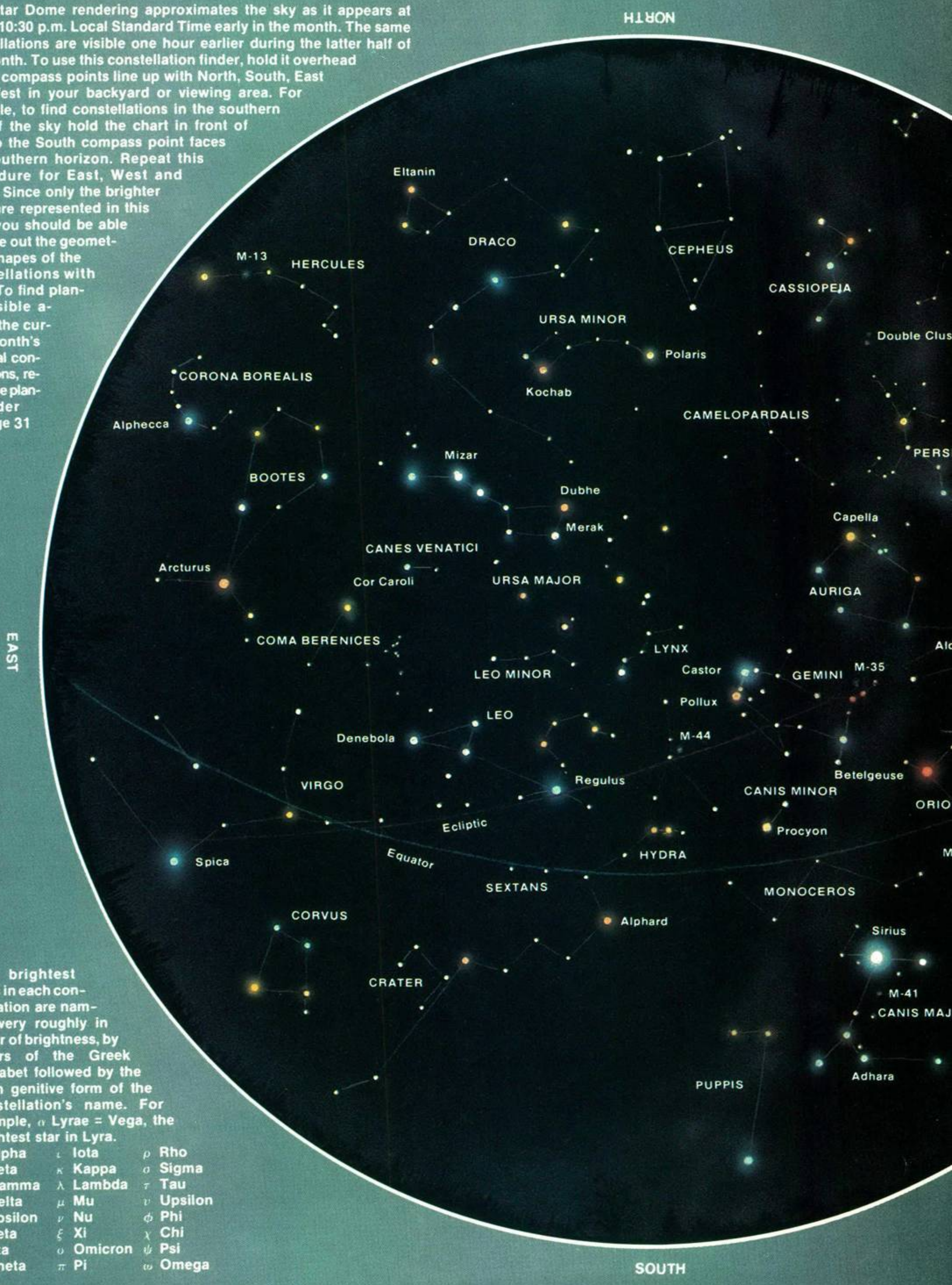
The movements of the five planets were closely watched in ancient times, for it was believed that their positions among the stars and relative to each other constituted divine messages to mankind. The names of the planets were the same as those of the principal gods themselves. Jupiter, now known to be the king indeed of the solar system, was named for the ruler of the gods: "Zeu-pater," father Zeus to the Greeks, identified with the Latin Jove and finally becoming Jupiter. Saturn, the Greek Kronos, was the ancient god of time, the father of Jupiter, and appropriately his planet moves the slowest among the stars.

According to the old myth, Saturn was once the ruler of the gods, but a prophecy declared that one of his children would replace him. To avoid such a *coup d'état*, Saturn prudently swallowed each of his children as soon as they were born! Understandably enough, his wife finally tired of Saturn's peculiar culinary habits, so when Jupiter was born, she hid the child and gave Saturn a stone to gulp down instead.

Jupiter went on to fulfill the prophecy, also releasing his brothers and sisters from Saturn's innards where, being gods and therefore unable to die, they had survived quite nicely — if in less than luxurious surroundings.

This tale has a strange scientific postlude. When Galileo first observed Saturn in his crude telescope, he

This Star Dome rendering approximates the sky as it appears at about 10:30 p.m. Local Standard Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets visible among the current month's zodiacal constellations, refer to the planet finder on page 31


NORTH
Eltanin
DRACO
CEPHEUS
M-13
HERCULES
CASSIOPEIA
URSA MINOR
Double Clus
Polaris
CORONA BOREALIS
Kochab
Alphecca
CAMELOPARDALIS
Mizar
PERS
BOOTES
Dubhe
Merak
Capella
CANES VENATICI
Arcturus
Cor Caroli
URSA MAJOR
AURIGA
EAST
COMA BERENICES
LYNX
Alc
Castor
GEMINI
M-35
LEO MINOR
Pollux
LEO
Denebola
M-44
Betelgeuse
Regulus
VIRGO
CANIS MINOR
ORIO
Ecliptic
Procyon
Spica
Equator
HYDRA
M
SEXTANS
MONOCEROS
CORVUS
Alphard
Sirius
CRATER
M-41
CANIS MAJ
Adhara
PUPPIS
SOUTH

Map Centered on 40° North Latitude

The brightest stars in each constellation are named, very roughly in order of brightness, by letters of the Greek alphabet followed by the Latin genitive form of the constellation's name. For example, α Lyrae = Vega, the brightest star in Lyra.

α Alpha
β Beta
γ Gamma
δ Delta
ε Epsilon
ζ Zeta
η Eta
θ Theta
ι Iota
κ Kappa
λ Lambda
μ Mu
ν Nu
ξ Xi
ο Omicron
π Pi
ρ Rho
σ Sigma
τ Tau
υ Upsilon
φ Phi
χ Chi
ψ Psi
ω Omega

ANDROMEDA
TRIANGULUM
Algol
ARIES
S
Pleiades
CETUS
Hyades
aran
TAURUS
WEST
Bellatrix
ERIDANUS
Rigel
LEPUS
COLUMBA

Map by Adolf Schaller

thought he saw a triple planet. Unable to discern the rings clearly, he saw Saturn flanked by two smaller bodies on either side — the lobes of the rings, fully open when his observation was made. This phenomenon he duly noted. But when a few years later he looked again, the two bodies had vanished! The rings, of course, were now edge-on and invisible, but Galileo didn't know that. Had Saturn swallowed his children again? Was the ancient myth true after all? Some say Galileo was so upset by what he saw that he wouldn't look at Saturn again!

1979 is one of those years when Saturn gulps down his offspring, for this year Earth passes through the plane of the rings. In a small telescope, Saturn will appear alone and unaccompanied once again.

Mars, the red planet, is named for the god of war (Ares to the Greeks). This may be because of its color, the color of fire and blood. Another factor may be Mars' tendency to change so greatly in brightness, waxing and waning like the tides of battle. When its two tiny satellites were discovered, they were appropriately named for the two steeds of war which drew Mars' chariot. The war-horses of Mars were Fear and Terror (Phobos and Deimos)!

Some readers have wondered why we don't indicate the planets on the Star Dome chart each month. One reason is that the planets, being wanderers, will change their position against the stars even over a period of a month. This is especially true of fast-moving Mars, which could be shown only for a specific day in the month. Instead, the Planet Finder locates the planets for each month, even if they are not visible at the time for which the chart is designed. Also the planets are easily distinguishable against the background of the stars. If you use even a little care, you can't mistake a planet for a star! The planets are usually brighter than any star, and most importantly, they don't twinkle as much.

If you're in doubt whether a particular star is a planet or not, compare its appearance to that of nearby stars. If it seems to shine with a clear steady light, not twinkling and flashing like the stars, then it's a planet.

The reason for this is that planets are not actually point sources like the stars. The light of a point source like a star is deflected and scattered by passage through Earth's atmosphere, and this causes the appearance of twinkling. But the light of planets comes from an extended disk, and so the scattering effect is averaged out over a certain area, resulting in less overall distortion of the constituent light rays. The result is less apparent twinkling.

We may no longer believe that Cypria sends down love from her third epicycle, but her clear steady light, like that of the other planets, is no less beautiful to our eyes!

Close-Up

Puppis

Puppis — together with Carina and Vela — once was part of the "superconstellation" of Argo Navis, and it is under that name that we must look for its wonders in the older observing guides. "A constellation of vast extent, the most brilliant objects of which are invisible in England" was Webb's introduction to this month's region. Barns noted: "The poop of the good ship Argo is brilliantly beaconed in this quarter and on southward as far as your latitude insures fair seeing, high altitudes having great advantage."

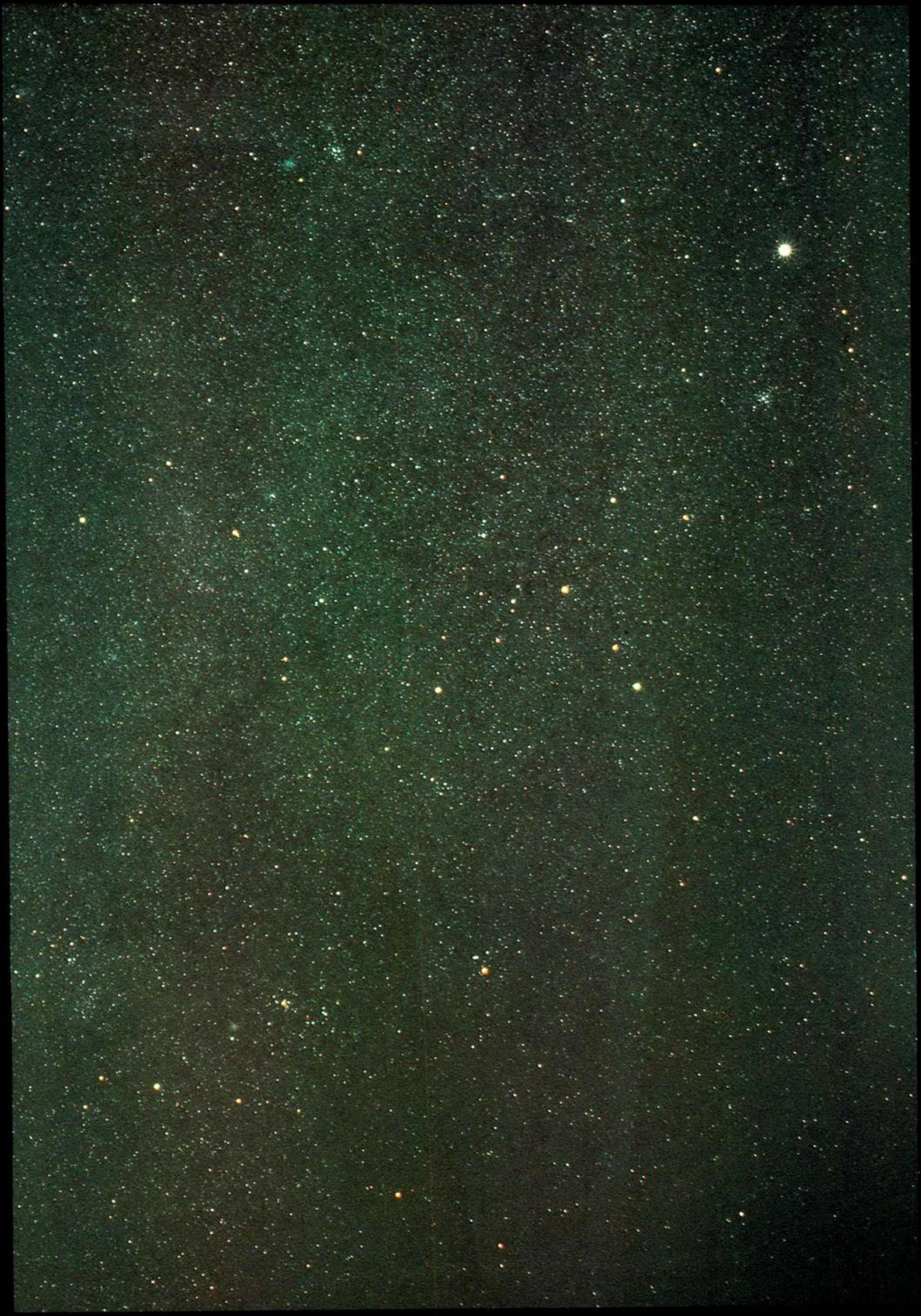
This celestial "rezoning" has not been without its problems for stargazers, as Muirden laments in his account of Puppis: "One of the fragments of Argo Navis, a splendid constellation, lying beyond Monoceros in the Milky Way and forming the south and east borders of Canis Major. It has been ill-treated by celestial cartographers and objects quoted in old catalogues as belonging to Puppis may now be found in any of the neighboring groups. Considerable revision is necessary, and it is worth taking trouble in identification, for the views will more than reward the effort involved."

Kappa (κ) Puppis

No better example of the little-known wonders awaiting those who would venture into low-lying regions like Puppis is the stunning double star, Kappa (κ) Puppis. Easily picked out with the unaided eye on a dark night, look for it roughly 7° (or ½ hour of R.A.) due east of the star Delta (δ) Canis Majoris.

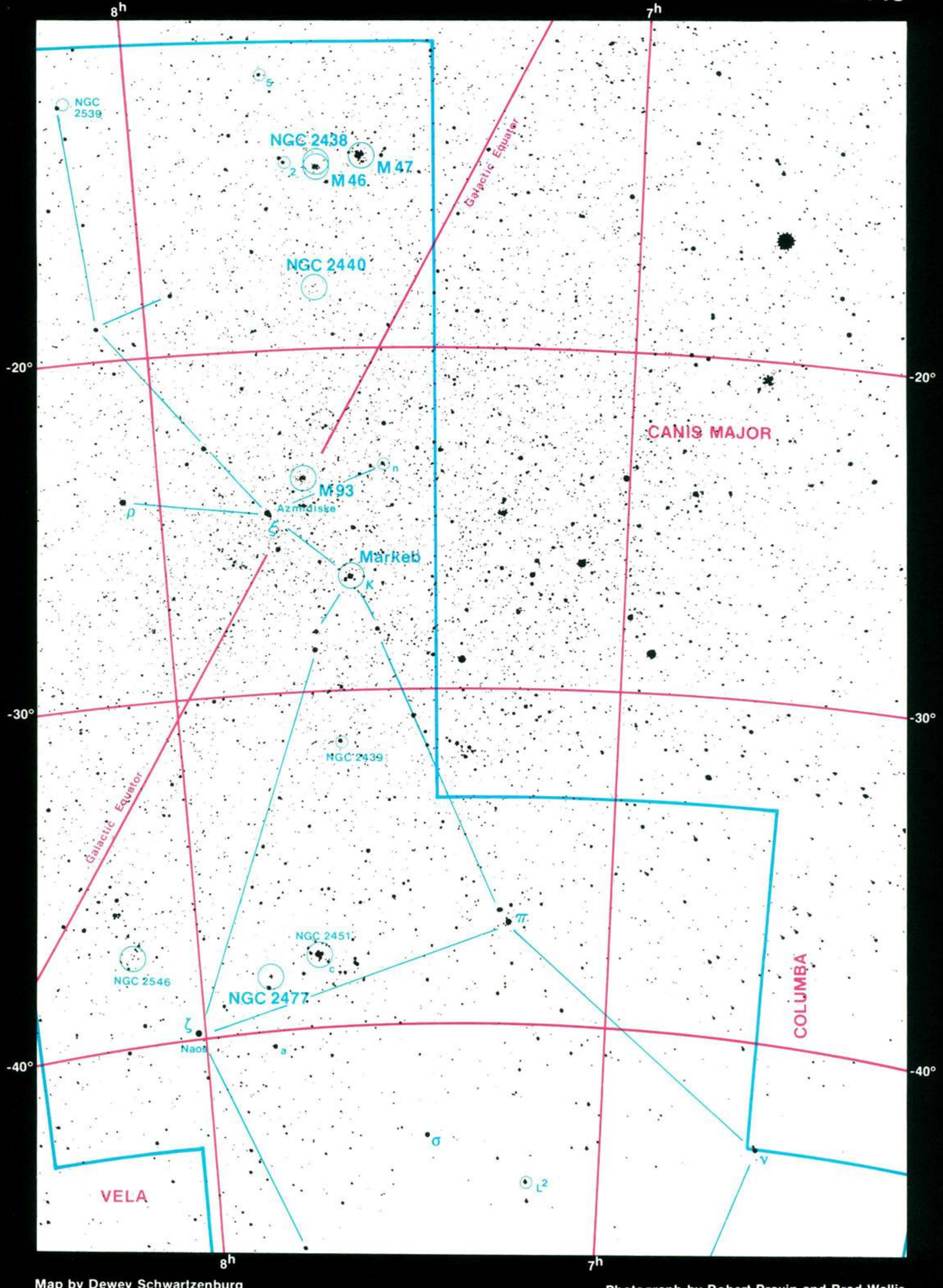
Greatly resembling the popular northern duo Gamma (γ) Arietis, this neglected showpiece consists of nearly matched (4.5 and 4.6 magnitude) white suns 10 seconds of arc apart near position angle 320° (northwest-southeast on the sky). Kappa is neatly split in a 2.4 or 3-inch refractor at 30 to 45 power when seeing is good. Lower magnification and poor seeing can combine to give a fascinating view of the two stars nearly touching each other and even at times merging together into a kind of cosmic egg!

Kappa Puppis seems little observed by amateurs and few published descriptions are to be found. Muirden called this object a "fine pair: both yellowish" and Webb simply noted their tints as "white or pale yellow."



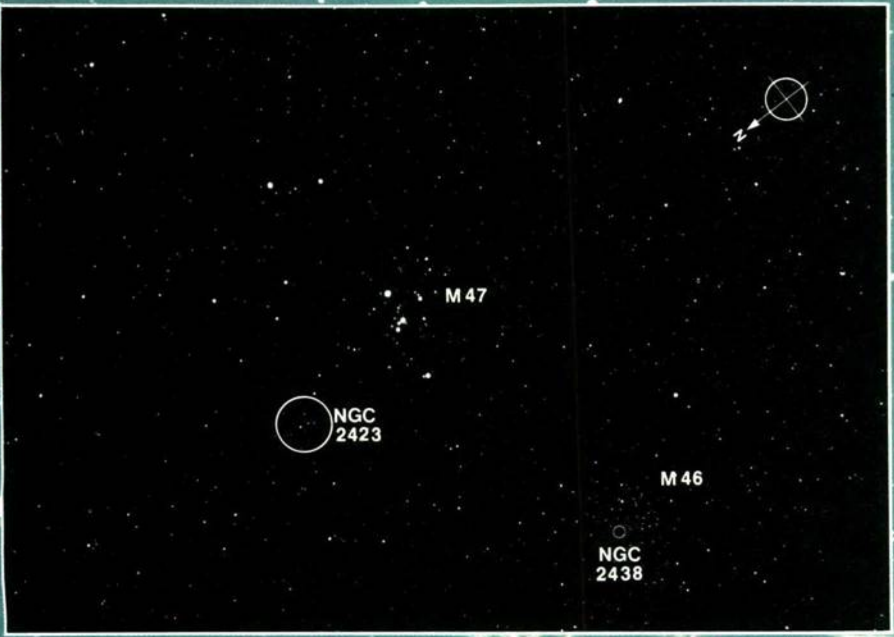
Epoch 1950 coordinates

PUPPIS


8h
7h
NGC 2539
5
NGC 2438
2
M 46
M 47
Galactic Equator
NGC 2440
-20°
-20°
CANIS MAJOR
n
M 93
ρ
Azmidiske
ζ
Markeb
κ
-30°
-30°
NGC 2439
Galactic Equator
π
NGC 2451
c
NGC 2546
NGC 2477
COLUMBA
ζ
Naos
a
-40°
-40°
σ
ν
L2
VELA
8h
7h

Map by Dewey Schwartzenburg

Photograph by Robert Provin and Brad Wallis



The open clusters M-46, M-47, and NGC-2423 are seen in this photograph by Paul Avellar. The planetary nebula NGC-2438 appears to be embedded in M-46, but is not actually associated with it. Puppis, often neglected by observers because of its southerly declination, offers many rich telescopic rewards.

Both components of this binary system are B-type suns. Were it placed higher in the sky, this beautiful duo would be on everyone's list of favorite doubles. Are you one of the many who have overlooked it?

M-93

Three of Messier's open star clusters lie within this month's constellation, and all are within easy reach of binoculars or a good finderscope. Most southerly of these is M-93, situated about 3° northeast of Kappa Puppis. Glowing near 6th magnitude, it hosts some 60 member suns in an area 20 minutes across.

M-93 is a striking object in anything from a 3-inch refractor to a 12-inch reflector, low to medium powers giving the most pleasing effect. Webb called it a "bright cluster in a rich neighborhood" and Muirden "a small cluster of bright and faint stars." Norton considered it a "loose cluster, fairly bright."

For a good modern account of this remote clan, we turn to that by John Mallas — an authority on the visual appearance of the Messier objects in small telescopes: "A glorious view... triangular in shape, with many colored stars. In the 4-inch (refractor) at low and medium power, M-93 is a compact swarm of stellar jewels."

Selected Objects — Puppis

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.
L^2	∩★	2.6-6.0	--	07^h12^m	-44°33′
n	★2	5.9/6.0	9″	07^h32^m	-23°22′
*M-47	○	4.5	25′	07^h34^m	-14°22′
*Markeb (κ)	★2	4.5/4.6	10″	07^h37^m	-26°41′
*M-46	○	6.0	30′	07^h40^m	-14°42′
*NGC-2438	■	11.3	68″	07^h40^m	-14°36′
*NGC-2440	■	11	54″x20″	07^h40^m	-18°05′
NGC-2439	○	7	9′	07^h40^m	-31°32′
*M-93	○	6.0	20′	07^h42^m	-23°45′
2	★2	6.1/6.8	17″	07^h43^m	-14°34′
NGC-2451(c)	○	3.6	45′	07^h44^m	-37°51′
5	★2	5.5/7.1	3″	07^h46^m	-12°04′
*NGC-2477	○?	5.7	25′	07^h50^m	-38°25′
NGC-2539	○	8.2	20′	08^h08^m	-12°41′
NGC-2546	○	4.6	40′	08^h11^m	-37°29′

*Detailed in Close-Up

∩★ = Irregular Variable
★2 = Double Star
○ = Open Cluster
■ = Planetary Nebula

NGC-2477

Before continuing our celestial journey northward to view the other two Messier clusters in Puppis, let's make a brief sidetrip (actually a plunge southward in the heavens!) to examine the puzzling cluster designated NGC-2477. Sweep for it with a low power eyepiece on the telescope just north of the star b Puppis, itself 2° northwest of Zeta (ζ).

This glittering commune shines at magnitude 5.7 and contains at least 300 stars within an area of 25 minutes. Although generally classified as a very rich and concentrated open cluster, NGC-2477 has been referred to as a possible globular by more than one authority. In his well-known catalog, Becvar lists this object under open clusters with the notation "globular?", and Robert Burnham, Jr. refers to it as "almost globular." Harlow Shapley considered it either one of the richest open clusters or one of the loosest globulars!

The NGC calls this object "remarkable" and describes it as a "cluster; bright, rich, large, little compressed, stars 12th magnitude and downwards." Chambers called it a "superb cluster" in his roster from the 1890s. Unfortunately, at its declination of -38° few others have ventured here to record their visual impressions. Even the published values for its distance leave uncertainty as to its true nature, varying from less than 3000 light-years to more than 6000.

Why not take a first-hand look yourself the next clear night and decide how NGC-2477 appears in your telescope — open or globular? Different apertures may well give different impressions. For best results, select a night having not only dark skies but also good seeing (image steadiness), and observe the cluster when on or very near the meridian (and therefore at its highest in the sky). Here's just one more example of the many mysteries and puzzles in the night sky awaiting the visual observer!

M-46 and NGC-2438

Nearly 9° due north of M-93 and just a degree west of the double star 2 Puppis (see table of selected objects), lies the open cluster M-46 and its associated planetary nebula NGC-2438. This beautiful spherical cloud of faint stars contains at least 150 members in an area 30 minutes across, and glows softly at magnitude 6.0. All are nearly of the same brightness, giving the cluster a very uniform appearance, and offering a superb sight in 4-inch and larger scopes.

Adding greatly to the interest of this cluster for telescopists is the dim planetary nebula NGC-2438, position-ed near its northern edge. This 11th magnitude object is 68 seconds in apparent size, and in large amateur instruments looks like a smaller and fainter version of the famed Ring Nebula (M-57) in Lyra. It can be glimpsed in a 4-inch glass at 100 power by a careful observer on a good night and is easily seen in a 10 or 12-inch reflector at 150 power. A well dark-adapted eye and the use of averted (side) vision helps greatly in detecting its presence.

Webb described this dual object as follows: “Beautiful circular cloud of small stars (10th magnitude — John Herschel), about ½° degree in diameter: best with low power... a feeble nebula on its northern verge, is in Lassell's 20 foot [24-inch] reflector ‘an astonishing and interesting object;’ he and the Earl of Rosse see it as annular; so Buffham, 9-inch (reflector).” The **NGC** calls the cluster itself a “remarkable” object.

Using his 10-inch reflector, Barns logged M-46 as an “annular star-cloud” without mentioning the nebula. Chambers found it a “loose cluster of small stars, 8th and 13th magnitude, with faint planetary nebula involved.” Norton recorded it as a “beautiful cluster of small stars...On its northern edge is the irregular planetary ring nebula NGC-2438,” and Brown remarked that the cluster is “dotted on its northern edge” by the planetary. Holyoke considered M-46 “a very beautiful galactic cluster...splendid in a 6-inch telescope at 100 power.” And again, Muirden saw it as “A large mass of faint stars, sprinkling the field of view with tiny points of light.”

Mallas' description of cluster and nebula as seen in his 4-inch refractor reads: “a magnificent cluster at low power. It is circular without any pronounced bunching of stars near the center, yet the brightest ones form many geometrical patterns. The planetary nebula is difficult to locate. It is oval, nonuniform in brightness, and blue-grey in color.” Despite its faintness compared to other members of its class, NGC-2438 appears on the list of the 35 finest planetaries given by Tom Reiland in the August 1977 issue of ASTRONOMY. This object also carries the Herschel designation H. IV 39, being the 39th entry in Sir William's class IV (planetary nebulae).

It may come as a surprise to learn that this unusual combination of deep-sky objects appears to be merely the result of a remarkable cosmic coincidence — the nebula and cluster differ greatly in their radial velocities and are, therefore, probably unrelated physically. In other words, we simply view both objects along the same line of sight from our vantage point. This is all the more remarkable when we note that at least one cluster member can be seen shining through the hole in the ring, just like a typical planetary with central star!

M-36 lies nearly 6000 light-years from us, amidst the glitter of the winter Milky Way. An observer properly stationed within the cluster and looking across the vast gulf toward us would see a ghostly smoke ring in the heavens, in the center of which would appear a faint yellow star — our Sun!

M-47

Slightly more than a degree west and somewhat north of M-46 is the third Messier cluster in Puppis, M-47. This is one of the notorious “missing” M objects — one that has finally been positively identified and returned to the catalog. It has the dubious distinction of having two NGC numbers — 2478 and 2422. The former is that assigned to Messier's original observation and the latter is the cluster that has been identified as the real M-47. (The problem resulted from an error in the position given by Messier for this object, which corresponds to an empty place on the sky.) Since NGC-2422 was discovered, or we should say “rediscovered,” by William Herschel during his great sweeps of the heavens, it also carries the designation H. VIII 38.

Webb described M-47 in his 3.7-inch refractor as a “Grand broad group, visible to naked eye, too large even for 64 [power]: some brilliant 5th or 6th magnitude stars, including Struve 1121....” The double referred to by Webb lies near the apparent center of the cluster, and consists of two 8th magnitude stars 7 seconds apart near position angle 305°.

Chamber's account of this object reads: “Bright neat cluster, with double star...A bright orange star precedes.” Barns saw it as a “Broad integration of magnitude 5-9 suns. Colorful units abound. A majestic zone throughout.” Muirden logged M-47 as “a brilliant, extensive, naked-eye group, somewhat diamond-shaped, containing the small pair Struve 1121,” and Norton called it a “loose cluster.” In all of the foregoing accounts, the observers were not aware that they were looking at Messier's lost 47th entry, but rather one of Herschel's many discoveries!

Among those aware of its identity, Mallas gave the following visual impression: “A beautiful coarse open cluster of bright stars, lying in the heart of the rich Puppis Milky Way. With the 4-inch, many colored stars were seen at low power.” Another was Holyoke, who stated that M-47 is a “fine object to restore to the (Messier) catalog” and called it an “excellent object.” This clan is at its sparkling best in a 4 to 6-inch richest-field telescope (RFT) at 15 to 25 power, with a field of 2° or more.

NGC-2440

We conclude our telescopic sampling of Puppis' treasure with a final stop at a little-known planetary nebula. This is NGC-2440, residing in comparative isolation at a point 3½° due south of M-46. Sweeping with a medium power eyepiece on a 4-inch or larger scope is the surest way to spot this object for the first time.

NGC-2440 is another of William Herschel's finds and is sometimes referred to as H. IV 64 from his catalog. It also appears on the list by Tom Reiland mentioned above as one of the 35 best examples of its class. Measuring some 54 by 20 seconds in size on photographs, it appears smaller as seen in the telescope. It also looks brighter than the 11.7 magnitude assigned to it as suggested in some of the descriptions below. Its official classification is “irregular, intermediate to diffuse nebulosity.”

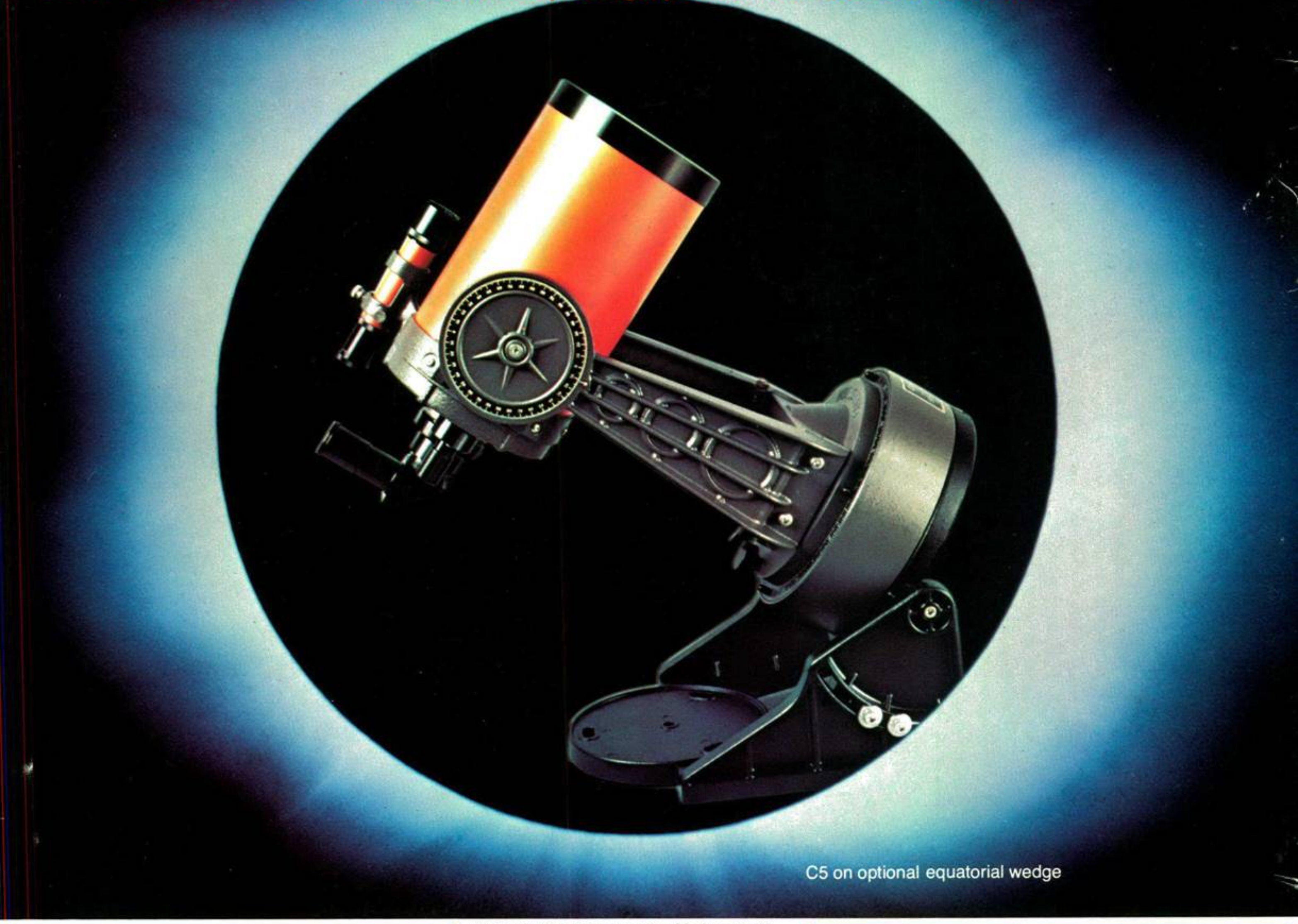
Webb's impression of NGC-2440 as seen in his 3.7-inch refractor was as follows: “planetary nebula, bright, pale bluish white. William Herschel: 12 or 15 seconds [diameter]. With my 64 [power], like a dull 8th magnitude star; with more power: small, brilliant, undefined, surrounded with a little very faint haziness. In a glorious neighborhood. Earl of Rosse: a red star 9-10 magnitude, following.”

Norton described this object similarly: “a bright, bluish planetary nebula, in a rich neighborhood, best seen with a moderately high power. A 10th magnitude ruddy star follows.” Barns called it a “curious bright oval” and Muirden a “small planetary nebula resembling a slightly hazy 8th magnitude star.”

Note in the accounts of NGC-2440 by Webb and Muirden that its light is said to resemble that of an 8th magnitude star. This is much brighter than the published magnitudes for this object, but agrees better with its appearance at the eyepiece. Why not make your estimates of its luster using nearby stars of known magnitude slightly out of focus for comparison?

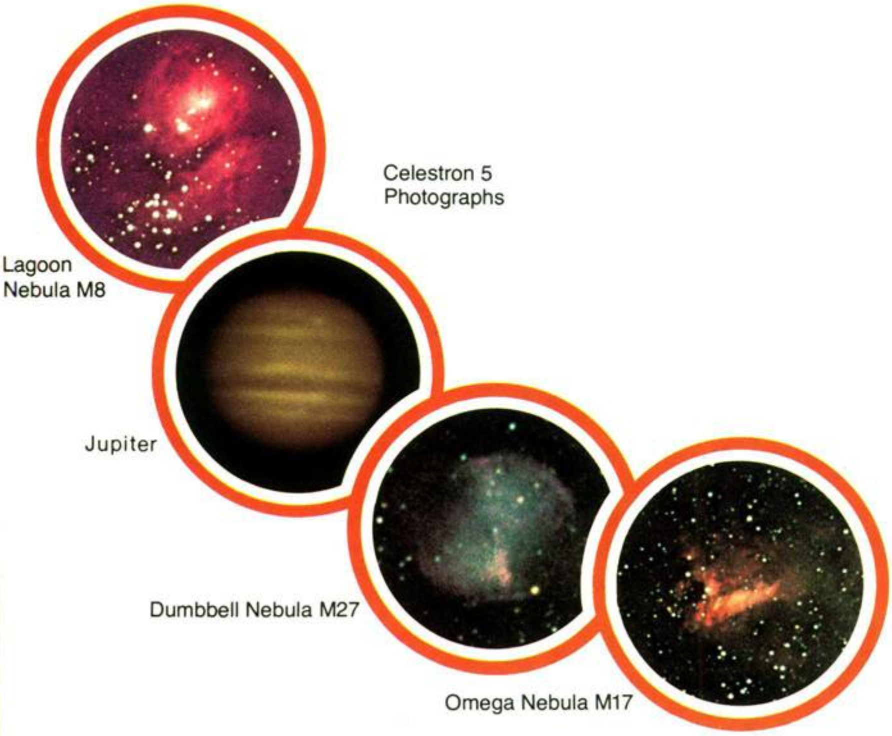
As in the case of Kappa Puppis, NGC-2440 would be much better known and observed were it placed higher in the sky. Few of today's stargazers have ever made its acquaintance, but those who have, seem eager to show it to others. This urge to share the wonders of the night with others is very real, as any star lover can tell you. It probably has something to do with the old English proverb that “a joy that's shared is a joy made double.” But it seems to go deeper than this. As astronomer Frank Bash puts it: “...like every astronomer I have ever met, I am evangelistic about my subject.”

Celestron 5 Smallest of Our Large Telescopes, Optimum for Nature Enthusiast, Telephotographer, or Amateur Astronomer.



C5 on optional equatorial wedge

"Your Window to the Universe"
Other models available 3½″ to 14″



Celestron 5
Photographs

Lagoon
Nebula M8

Jupiter

Dumbbell Nebula M27

Omega Nebula M17

Send $2.00 for 32-page full color catalog
on how to select & use a Celestron telescope

Celestron

Celestron International
2835 Columbia Street
Box 3578 B
Torrance, Ca. 90503
(213) 328-9560